RSG INC.
ENVIRONMENT, ENERGY, & ACOUSTICS

Noise Impact Study for Kingdom Community Wind:

Lowell, Vermont

May 2010

DATA ■ ANALYSIS ■ SOLUTIONS

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1.0 INTRODUCTION

The Kingdom Community Wind Project proposes to construct and operate up to 21 wind turbines in Lowell, Vermont. The total capacity of the system would be up to 63 MW with each turbine generating up to 3 MW. This study assessed the affects of wind turbines on sound levels in the surrounding area. The report includes:

1) A description of the project site
2) A noise primer
3) A discussion of noise issues specific to wind turbines
4) A discussion of applicable noise limits
5) The results of background sound level monitoring
6) The results of computer propagation modeling
7) Summary and conclusions

2.0 PROJECT DESCRIPTION

The proposed turbines would be located along an approximately 3.2 mile portion of the Lowell Mountain range in Lowell, Vermont. Parallel to the eastern side of the ridge is VT 14 which runs through the village of Albany. VT 100 runs parallel to the western side of the ridge. North of the project is Irish Hill Road, and the town line between Lowell and Eden is located to the south.

The closest residences[1] are to the northwest and east of the project. To the northwest, the Day residence at the end of Farm Road is approximately 3,520 feet from the nearest turbine. To the east, the residence at 1064 Eden Road is approximately 3,380 feet from the nearest turbine.

A map of the project area is provided in Figure 1.

3.0 A NOISE PRIMER

3.1 What is Noise?

Noise is defined as "a sound of any kind, especially when loud, confused, indistinct, or disagreeable."[2] Passing vehicles, a noisy refrigerator, or an air conditioning system are sources of noise which may be bothersome or cause annoyance. These sounds are a part of generally accepted everyday life, and can be measured, modeled, and, if necessary, controlled.

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[1] Residences exclude seasonal camps

[2] "The American Heritage Dictionary of the English Language," Houghton Mifflin Company, 1981.

Figure 1: Proposed Project and Surrounding Area

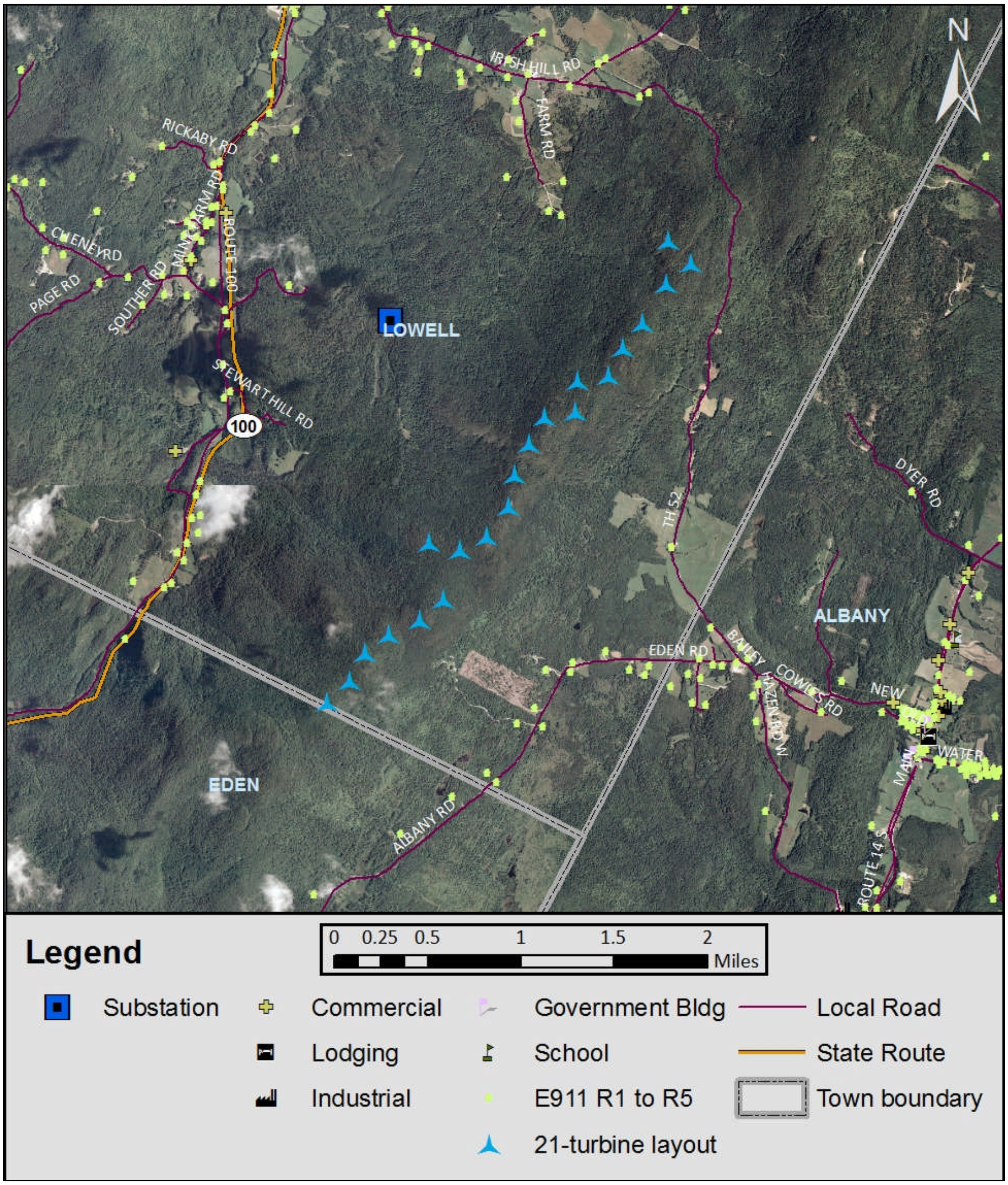


Figure 2: Basic Theory: Common Sounds in Decibels

3.2 How is Sound Described?

Sound is caused by variations in air pressure at a range of frequencies. Sound levels that are detectable by human hearing are defined in the decibel (dB) scale, with 0 dB being the threshold of human hearing, and 135 dB causing pain and permanent damage to the ear. Figure 2 shows the sound levels of typical activities that generate noise.

The decibel scale can be weighted to mimic the human perception of certain frequencies. The most common of these weighting scales is the "A" weighting, and this scale is used most frequently in environmental noise analysis. Sound levels that are weighted by the "A" scale have units of dBA or dB(A).

To account for changes over time, a weighted average sound level called the "equivalent" sound level (L_{eq}) is often used. L_{eq} averages sound pressure rather than decibels, and results in weighting loud and infrequent noises more heavily than quieter and more frequent noises. For example, a train passing by for one minute out of an hour could produce sound levels around 90 dBA while passing by, but the equivalent sound level for the entire hour would be 72 dBA. L_{eq} is also often used in environmental noise analysis.

3.3 What is the Difference between Sound Pressure Levels and Sound Power Levels?

Both sound power and sound pressure levels are described in terms of decibels, but they are not the same thing. Sound power is a measure of the acoustic power emitted or radiated by a source. The sound power level of a source does not change with its surrounding conditions.

Sound pressure level is observed at a specific location and is related to the difference in air pressure above or below atmospheric pressure. This fluctuation in air pressure is a result of the sound power of a source, the distance at which the sound pressure level is being observed, and the characteristics of the path and environment around the source and receiver. When one refers to sound level, they are generally speaking of the perceived level, or sound pressure level.

For example, a coffee grinder will have the same sound power whether or not it is grinding indoors or outdoors. The amount of sound the coffee grinder generates is always the same. However, if you are standing six feet away from the coffee grinder indoors, you would experience a higher sound pressure level than you would if you were six feet away from the coffee grinder outdoors in an open field. The reason for this is that the sound being emitted from the coffee grinder would bounce off walls and other surfaces indoors which would cause sound to build up and raise the sound pressure level.

Sound power cannot be directly measured. However, since sound pressure and sound power are related, sound power can be calculated by measurements of sound pressure and sound intensity. It can be helpful to note that over soft ground outside, the sound pressure level of a small source observed 50 feet away is roughly 33 dB lower than its sound power level.

3.4 How is Sound Modeled?

The decibel sound level is on a logarithmic scale. One manifestation of this is that sound *power* increases by a factor of 10 for every 10 dB increase. However, for every 10 dB increase in sound pressure level, we *perceive* an approximate doubling of loudness. Small changes in sound pressure level, below 3 dB, are generally not perceptible.

For a point source, sound level diminishes or attenuates by 6 dB for every doubling of distance due to geometrical divergence. For example, if an idling truck is measured at 50 feet as 66 dBA, at 100 feet the level will decline to 60 dBA, and at 200 feet, 54 dBA, assuming no other influences. From a line source, like a gas pipeline or from closely spaced point sources, like a roadway or string of wind turbines, sound attenuates at approximately 3 dB per doubling distance. These "line sources" transition to an attenuation of 6 dB per doubling at roughly a distance of roughly a third of the length of the line source.

Other factors, such as intervening vegetation, terrain, walls, berms, buildings, and atmospheric absorption will also further reduce the sound level reaching the listener. In each of these, higher frequencies will attenuate faster than lower frequencies. Finally, the ground can also have an impact on sound levels. Harder ground generally increases and softer ground generally decreases the sound level at a receiver. Reflections off of buildings and walls can increase broadband sound levels by as much as 3 dB.

If we add two equal sources together, the resulting sound level will be 3 dB higher. For example, if one machine registers 76 dBA at 50 feet, two co-located machines would register 3 dB more, or 79 dBA at that distance. In a similar manner, at a distance of 50 feet, four machines, all operating at the same place and time, would register 82 dBA and eight machines would register 85 dBA. If the two sources differ in sound level then 0 to 3 dB will be added to the higher level as shown in Table 1.

Table 1: Decibel Addition

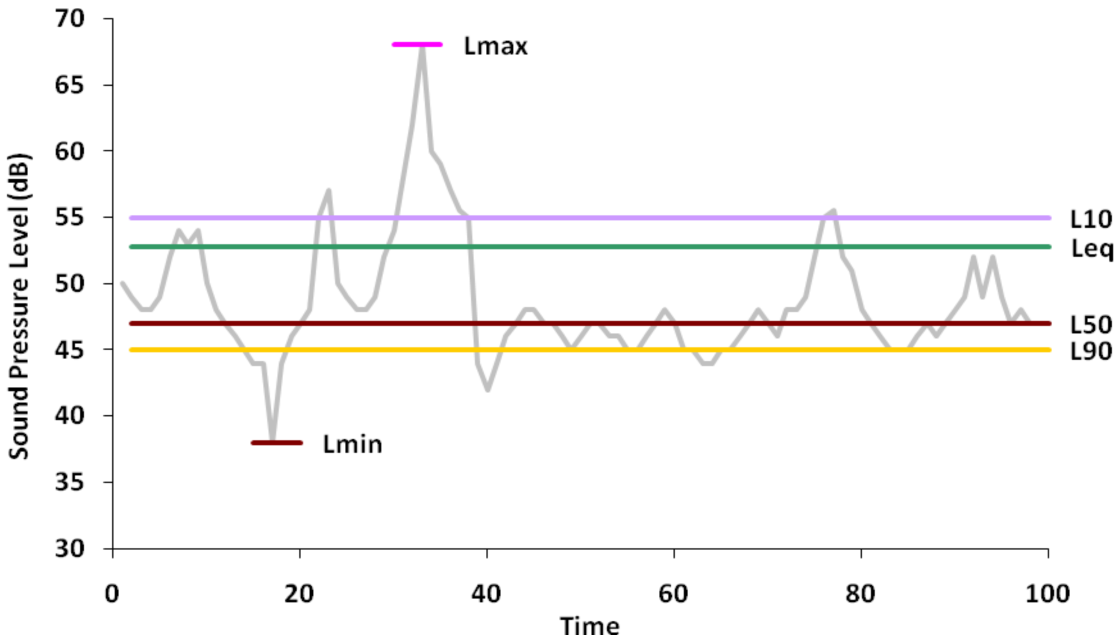
If Two Sources Differ By	Add
0-1 dB	3 dB
2-4 dB	2 dB
5-9 dB	1 dB
>9 dB	0 dB

3.5 Description of Terms

Sound can be measured in many different ways. Perhaps the simplest way is to take an instantaneous measurement, which gives the sound pressure level at an exact moment in time. The level reading could be 62 dB, but a second later it could 57 dB. Sound pressure levels are constantly changing. It is for this reason that it makes sense to describe noise and sound in terms of time.

The most common ways of describing noise over time is in terms of various statistics. Take, as an example, the sound levels measured over time shown in Figure 3. Instantaneous measurements are shown as a ragged grey line. The sound levels that occur over this time can be described verbally, but it is much easier to describe the recorded levels statistically. This is done using a variety of "levels" which are described below.

Figure 3: Example of Noise Measurement over Time and Descriptive Statistics



3.5.1 Equivalent Average Sound Level - Leq

One of the most common ways of describing noise levels is in terms of the continuous equivalent sound level (Leq). The Leq is the average of the sound pressure over an entire monitoring period and expressed as a decibel. The monitoring period could be for any amount of time. It could be one second ($Leq_{1\text{-sec}}$), one hour ($Leq_{(1)}$), or 24 hours ($Leq_{(24)}$). Because Leq describes the average pressure, loud and infrequent noises have a greater effect on the resulting level than quieter and more frequent noises. For example, in Figure 3, the median sound level is about 47 dBA, but the equivalent average sound level (Leq) is 53 dBA. Because it tends to weight the higher sound levels and is representative of sound that takes place over time, the Leq is the most commonly used descriptor in noise standards and regulations.

3.5.2 Percentile Sound Level - Ln

Ln is the sound level exceeded *n* percent of the time. This type of statistical sound level, also shown in Figure 3, gives us information about the distribution of sound levels over time. For example, the L10 is the sound level that is exceeded 10 percent of the time, while the L90 is the sound level exceeded 90% of the time. The L50 is exceeded half the time. The L90 is a residual base level which most of the sound exceeds, while the L10 is representative of the peaks and higher, but less frequent levels. When one is trying to measure a continuous sound, like a wind turbine, the L90 is often used to filter out other short-term environmental sounds that increase the level, such as dogs barking, vehicle passbys, wind gusts, and talking. That residual sound, or L90, is then the sound that is occurring in the absence of these noises.

3.5.3 Lmin and Lmax

Lmin and Lmax are simply the minimum and maximum sound level, respectively, monitored over a period of time. These are shown in Figure 3.

4.0 NOISE STANDARDS

4.1 Local and State Standards

There is no quantitative noise standard in the Town of Lowell Zoning Bylaw or the Lowell Town Plan.

There are no state statutes or regulations that establish quantitative noise standards which are applicable to this project.

4.2 World Health Organization

The United Nation's World Health Organization (WHO) has published "Guidelines for Community Noise" (1999) which uses the most current research on the health impacts of noise to develop guideline sound levels for communities. The forward of the report states, "The scope of WHO's effort to derive guidelines for community noise is to consolidate actual scientific knowledge on the health impacts of community noise and to provide guidance to environmental health authorities and professionals trying to protect people from the harmful effects of noise in non-industrial environments."

The WHO guidelines suggest a daytime and nighttime protective noise level. During the day, the levels are 55 dBA $Leq_{(16)}$, that is, an average over a 16-hour day, to protect against serious annoyance and 50 dBA $Leq_{(16)}$ to protect against moderate annoyance.

During the night, the WHO recommends limits of 45 dBA $Leq_{(8)}$ and an instantaneous maximum of 60 dBA LAfmax (fast response maximum). These are to be measured outside the bedroom window. These guidelines are based on the assumption that sound levels indoors would be reduced by 15 dBA with windows open. That is, sound level inside the bedroom that is protective of sleep is 30 dBA $Leq_{(8)}$. So long as the sound levels outside of the house remain at or below 45 dBA, sound levels in the bedroom will remain below 30 dBA. Given the climate in this region, this is essentially a summertime standard, since residents are less likely to have their windows open during other times of the year. By closing windows, an additional ~10 dB of sound attenuation will result.

Table 4.1 of the WHO's "Guidelines for Community Noise" (1999) provides guideline values for community noise in specific environments. This table is provided in the Appendix.

In October, 2009, WHO Europe conducted an updated literature review and developed guidelines for nighttime noise in Europe. They expanded on the 1999 WHO guidelines by adding an *annual average* nighttime guideline level to protect against adverse effects on sleep disturbance. This guideline is 40 dB L night, outside.

4.3 Federal Standards and Guidelines

There are no federal standards that apply to wind turbines on private land. Many federal agencies have adopted guidelines and standards that apply to other types of facilities. A summary of some of these standards is shown in Table 2. Note that these standards are in terms of Leq, Ldn, or L10. The Leq is the pressure weighted average sound level, over a specified period of time. The Ldn is the A-weighted day-night Leq, where a penalty of 10 dB is applied to nighttime sound. The L10 is the 10th percentile sound level. It is the level that is exceeded 10% of the time, and thus represents the higher sound levels over a period of time.

Table 2: Summary of Federal Guidelines and Standards for Exterior Noise

Agency	Applies to	Standard (dBA)
Environmental Protection Agency	Guideline to protect public health and welfare with an adequate margin of safety	55 dB Ldn
Bureau of Land Management (BLM)	Guidelines for the development of wind turbines on federal lands managed by BLM	Refers to the EPA 55 dB Ldn guideline.
Federal Energy Regulatory Commission (FERC)	Compressor facilities under FERC jurisdiction	55 dB Ldn
Federal Highway Administration (FHWA)	Federally funded highway projects. For "Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose."	57 dBA Leq or 60 dBA L10 during the peak hour of traffic. Either standard can be used, but not both.
	For "picnic areas, recreation areas, playgrounds, active sports areas, parks, residences, hotels, motels, schools, libraries, churches, and hospitals."	67 dBA Leq or 70 dBA L10
Federal Interagency Task Force	This Taskforce is set up to develop consistency of noise standards among federal agencies	55 to 65 dB Ldn for impacts on residential areas

The United States Department of the Interior, Bureau of Land Management (BLM) has developed a Programmatic Environmental Impact Statement (PEIS) for Wind Energy Development on BLM Lands in the Western United States. Noise is addressed in several sections of the PEIS. Several relevant points made in the PEIS are listed below:

- From Section 4.5.1: "at many wind energy project sites on BLM-administered lands, large fluctuations in broadband noise are common, and even a 10-dB increase would be unlikely to cause an adverse community response. In addition, noise containing discrete tones (tonal noise) is much more noticeable and more annoying at the same relative loudness level than other types of noise, because it stands out against background noise."
- From Section 4.5.2: "In general, background noise levels (i.e., noise from all sources not associated with a wind energy facility) are higher during the day than at night. For a typical rural environment, background noise is expected to be approximately 40 dB(A) during the day and 30 dB(A) at night (Harris 1979), or about 35 dB(A) as DNL (Miller 2002)."

- From Section 4.5.4: "The EPA guideline recommends an Ldn of 55 dB(A) to protect the public from the effect of broadband environmental noise in typically quiet outdoor and residential areas (EPA 1974). This level is not a regulatory goal but is 'intentionally conservative to protect the most sensitive portion of the American population' with 'an additional margin of safety.' For protection against hearing loss in the general population from non-impulsive noise, the EPA guideline recommends an Leq of 70 dB(A) or less over a 40-year period."
- From Section 5.5.3.1: "aerodynamic noise is the dominant source from modern wind turbines (Fégeant 1999)."
- From Section 5.5.3.1: "Considering geometric spreading only, this results in a sound pressure level of 58 to 62 dB(A) at a distance of 50 m (164 ft) from the turbine, which is about the same level as conversational speech at a 1 m (3 ft) distance. At a receptor approximately 2,000 ft (600 m) away, the equivalent sound pressure level would be 36 to 40 dB(A) when the wind is blowing from the turbine toward the receptor. This level is typical of background levels of a rural environment (Section 4.5.2). To estimate combined noise levels from multiple turbines, the sound pressure level from each turbine should be estimated and summed. Different arrangements of multiple wind turbines (e.g., in a line along a ridge versus in clusters) would result in different noise levels; however, the resultant noise levels would not vary by more than 10 dB."
- From Section 5.5.3.1: "In general, the effects of wind speed on noise propagation would generally dominate over those of temperature gradient."
- From Section 5.5.3.1: "Wind-generated noise would increase by about 2.5 dB(A) per each 3 ft/s (1 m/s) wind speed increase (Hau 2000); the noise level of a wind turbine, however, would increase only by about 1 dB(A) per 3 ft/s (1 m/s). In general, if the background noise level exceeds the calculated noise level of a wind turbine by about 6 dB(A), the latter no longer contributes to a perceptible increase of noise. At wind speed of about 33 ft/s (10 m/s), wind-generated noise is higher than aerodynamic noise. In addition, it is difficult to measure sound from modern wind turbines above a wind speed of 26 ft/s (8 m/s) because the background wind-generated noise masks the wind turbine noise at that speed (DWIA 2003)."
- From Section 6.4.1.6: "Noise generated by turbines, substations, transmission lines, and maintenance activities during the operational phase would approach typical background levels for rural areas at distances of 2,000 ft (600 m) or less and, therefore, would not be expected to result in cumulative impacts to local residents."

These statements from the BLM's Wind Energy Development PEIS do not represent a regulatory standard itself, but they do provide some insight on how one federal agency is approaching noise generated from wind turbine projects. This project is designed to be consistent with the BLM guidelines.

4.4 National Academy of Sciences Study

In 2008, the National Research Council of the National Academy of Sciences issued a report "Environmental Impacts of Wind-Energy Projects." This report summarized the state of understanding of wind energy projects with respect to its ecological and human impacts, the latter of which includes noise.

With respect to noise, the report concludes,

> "Noise produced by wind turbines generally is not a major concern for humans beyond a half mile or so because various measures to reduce noise have been implemented in the design of modern turbines. The mechanical sound emanating from rotating machinery can be controlled

> by sound-isolating techniques. Furthermore, different types of wind turbines have different noise characteristics. As mentioned earlier, modern upwind turbines are less noisy than downwind turbines. Variable-speed turbines (where rotor speeds are lower at low wind speeds) create less noise at lower wind speeds when ambient noise is also low, compared with constant-speed turbines. Direct-drive machines, which have no gearbox or high speed mechanical components, are much quieter."

The Kingdom Community Wind project is proposing to use variable speed upwind turbines. The gearbox and other mechanical components include noise isolation to reduce impacts.

4.5 Congressional Research Service

In June, 2008, the Congressional Research Service prepared a report to Congress entitled, "Wind Power in the United States: Technology, Economic, and Policy Issues." With respect to noise, that report concluded,

> "In addition to the visual impacts, there are other objections. All wind turbines produce mechanical and aerodynamic noise. Noise is thus a siting criterion for regulatory purposes. Early wind turbine models were often loud, especially downwind versions (blades behind the generator). Newer models are designed to minimize noise. Like visual aesthetics, wind turbine noise is often a matter of individual preferences and tolerances. For residences over 1 kilometer (0.6 miles) from a wind turbine, noise is generally not an issue."

4.6 Public Board Precedents

The two major precedent established by the Public Service Board are the Certificate of Public Good for the Sheffield Wind Project (Docket No. 7156) and Deerfield Wind Project (Docket 7250). The noise standard in the Deerfield Certificate for Public Good reads,

28. Deerfield shall construct and operate the Project so that the turbines emit no prominent discrete tones pursuant to ANSI standards at the receptor locations; and Project- related sound levels at any existing surrounding residences do not exceed 45 dBA(exterior)(Leq)(1 hr) or 30 dBA (interior bedrooms)(Leq)(1 hr).
29. In the event noise from operation of the Project exceeds the maximum allowable levels, Deerfield shall take all remedial steps necessary to bring the sound levels produced by the turbine(s) into compliance with allowable levels, including modification or cessation of turbine(s) operation.
30. Deerfield shall submit to the Board for review and approval a noise monitoring plan to be implemented during the first full year of operation. The Plan shall establish a monitoring program to confirm under a variety of seasonal and climactic conditions compliance with the maximum allowable sound levels described above.

The Sheffield standard is similar, but includes the King George School in the locations for which the standard is applied.

4.7 Noise Threshold Goals for Kingdom Community Wind

The EPA Guidelines, the BLM PEIS, and the WHO Guidelines each provide relevant noise criteria for a project of this type. Given the scientific evidence regarding sleep disturbance and other impacts that were reviewed by WHO, we propose that the project should meet a standard of 45 dBA $Leq_{(8)}$[1], which is averaged over the entire night (11 pm to 7 am) outside the residence. This would not apply to areas that have transient uses such as driveways, trails, farm fields, and parking areas. This standard is more stringent than all of the federal guidelines mentioned above and will be well below the level that can cause hearing impairment. This noise limit is both protective of human health and prevents any quality-of-life concerns.

We recognize the importance of the precedents established in the Sheffield and Deerfield cases, and thus we will compare the wind farm impacts to a standard of 45 dBA at the exterior of residences and schools, averaged over a one-hour period. This is a stricter standard than WHO in that it does not allow any hour to exceed 45 dBA, while the WHO guideline allows for levels above 45 dBA so long as the average over the night does not exceed 45 dBA.

5.0 EXISTING NOISE ENVIRONMENT

5.1 Soundscapes around the Project

Soundscapes are the combination of sounds that characterize a listening environment. Soundscapes can be distinguished by the types and levels of ambient sound over time. In a rural project area, differences in soundscapes are often a function of the distance from roadways of varying traffic volumes. In this area, sound level monitoring locations were chosen to represent distinctive soundscapes around the project area. These characteristic soundscapes include the:

1. Area directly east of the project on Bayley-Hazen Road and Eden Road
2. Closest residential area to the north on Irish Farm Road (a.k.a. Farm Road)
3. Area west of the project along VT 100
4. Area further west of the project along Cheney Road.

Sound level monitors were installed around these areas to determine existing ambient sound levels.

5.2 Background Sound Monitoring

To determine the existing ambient sound levels in the area, sound level monitoring was completed for six locations around the project area (Figure 3). Monitoring for sites 1A, 2, 3, 4, and 5 was conducted from October 23 to October 30, 2009. Site 6 was monitored from February 19 to 25, 2010. Site 1, the Nelson residence, was monitored again at a slightly different location near the residence on March 11 to 17, 2010.

All sites were monitored with ANSI Type 1 Cesva SC310 sound level meters set to log 1/3 octave band sound levels every one second or ANSI Type 2 Rion NL-22 sound level meters set to log equivalent average sound levels every 10 seconds. Each sound level meter was calibrated before and after the measurements and fitted with seven-inch water resistant windscreens. The windscreens reduce the self-noise created by wind passing over the meter's microphone. Each microphone was placed between 1.0 and 1.4 meters above the ground. In each case, the ground was considered "soft", that is, it was suitable

[1] The sleep disturbance standard used here is based on a windows-open condition. During the seasons when windows are generally closed, the standard is 10 dB higher, to account for the additional attenuation of closed windows.

for the growth of vegetation. The October monitoring took place in the late fall, when some leaves were still on the trees. During the February and March monitoring, the trees were bare.

The sound level meter model, start time, and end time for each monitoring location are shown in Table 3.

During the October monitoring period, wind speeds were collected at a ground level station next to Monitor 4. Wind speed and temperature during this period from the ground level station is shown in Figure 4. There was a period of moderate to heavy rain from 8:00 PM on October 23rd to 2:30 AM on October 25th. This was followed by gusty winds from 2:30 AM to 5:30 PM on October 25th.

Each monitoring location and logged sound levels are shown in greater detail in the section that follows.

Table 3: Background Sound Monitor Summary

Monitor	Meter	Start Time	End Time
1A	Rion NL22	10/23/09 11:04 AM	10/30/09 12:07 PM
1B	Rion NL22	3/11/10 12:12 PM	3/17/10 11:31 AM
2	Cesva SC310	10/23/09 11:22 AM	10/30/09 12:54 PM
3	Rion NL22	10/23/09 1:16 PM	10/30/09 2:40 PM
4	Cesva SC310	10/23/09 1:46 PM	10/30/09 3:02 PM
5	Rion NL22	10/23/09 2:16 PM	10/30/09 3:30 PM
6	Rion NL22	2/19/10 1:20 PM	2/25/10 10:54 AM

Figure 3: Sound Monitoring Locations

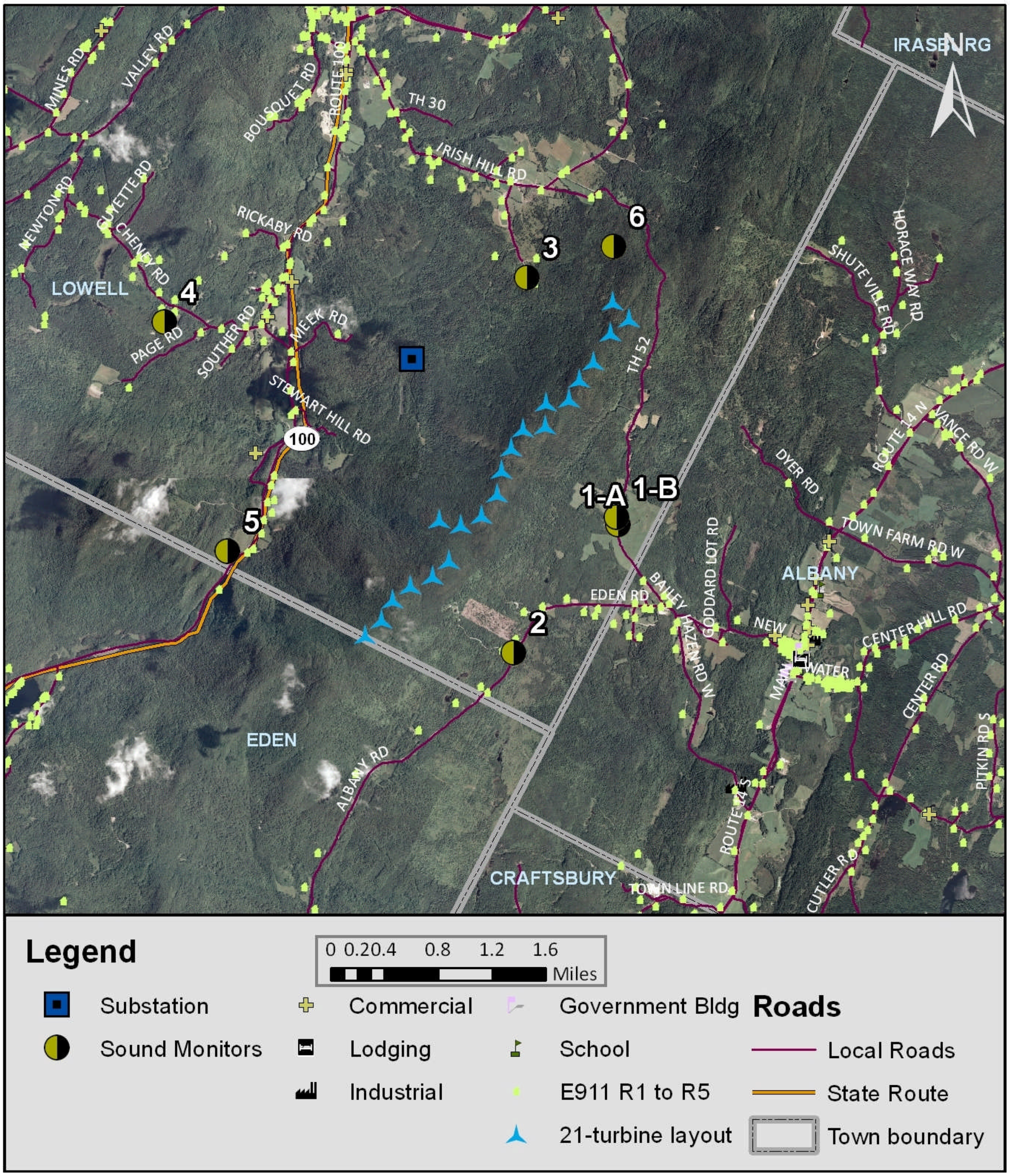
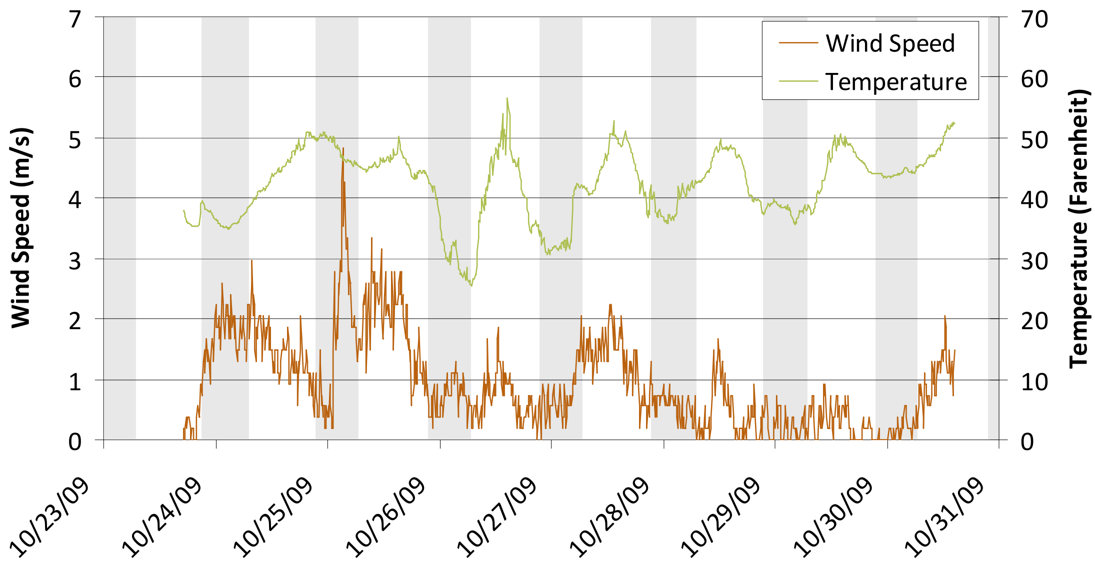


Figure 4: Wind Speed and Temperature at Ground Level Station at Monitor E (10-minute average)



5.2.1 Monitoring Location 1 – Nelson Farm

Monitors 1-A and 1-B were located at the Nelson residence on the eastern side of the project area on Bayley-Hazen Road. Monitor 1-A was set out for the first monitoring period and was located near a birch tree next to a pond on the property (Figure 5). The monitor was approximately 95 feet north of a creek. At the property owner's request, a second location was monitored at a fenceline near the residence, 350 feet north of the creek (Figure 7). The monitor was co-located with a portable met station, recording wind speed, wind direction, and temperature. The monitoring results for 1-A and 1-B are provided in Figure 6 and Figure 8, respectively.

Figure 5: Location of Monitor 1-A

Figure 6: Sound Pressure Levels (10-min, dBA) at Monitor 1-A

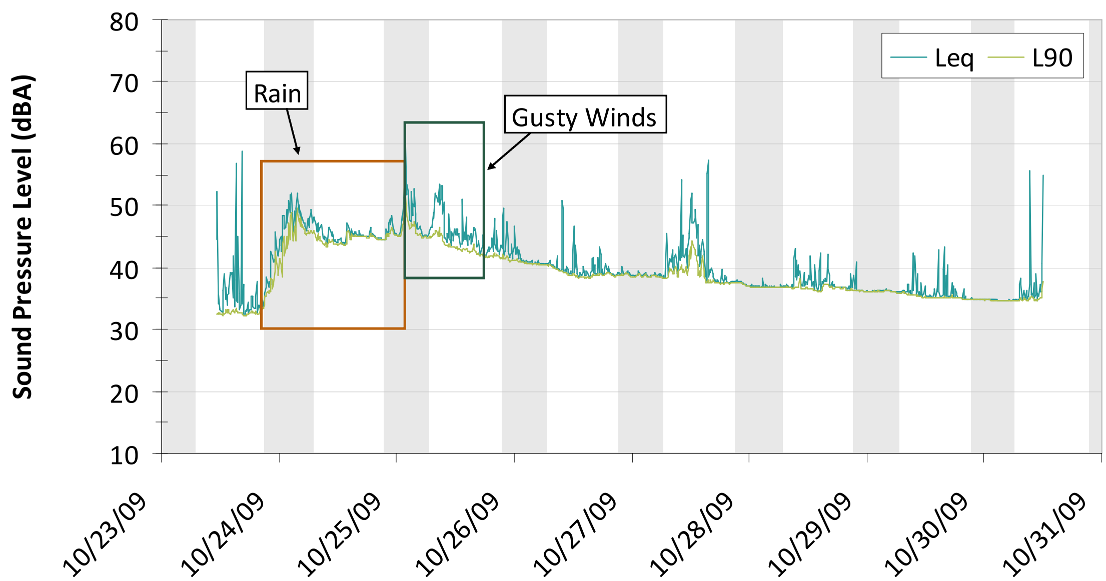


Figure 7: Location of Monitor 1-B

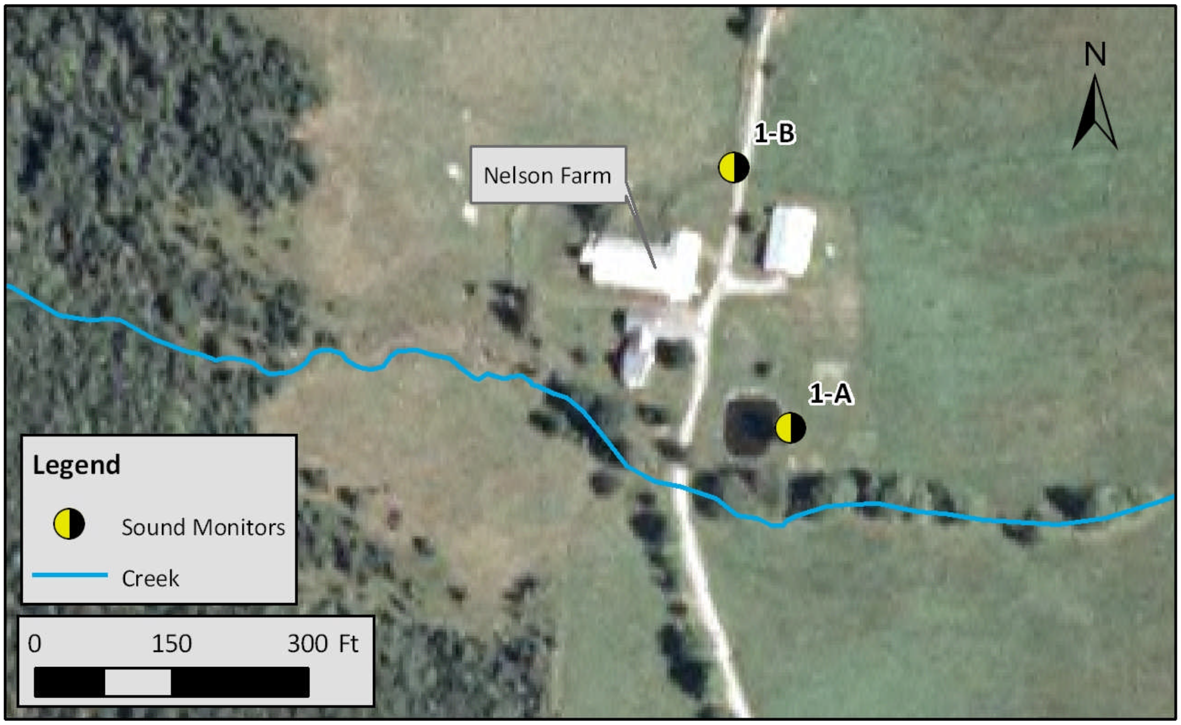
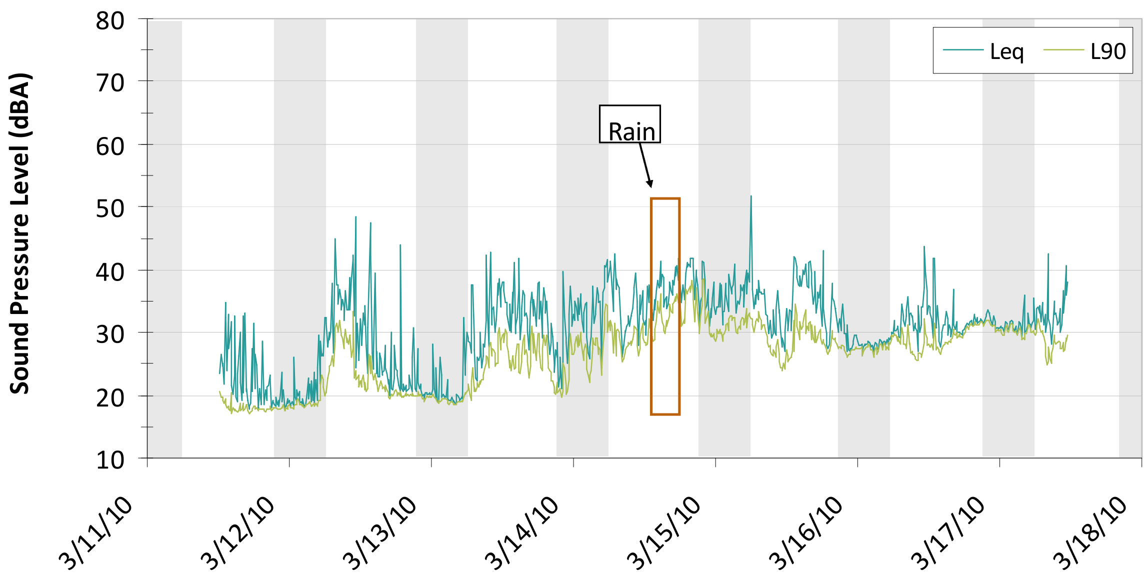


Figure 8: Sound Pressure Levels at Monitor 1-B

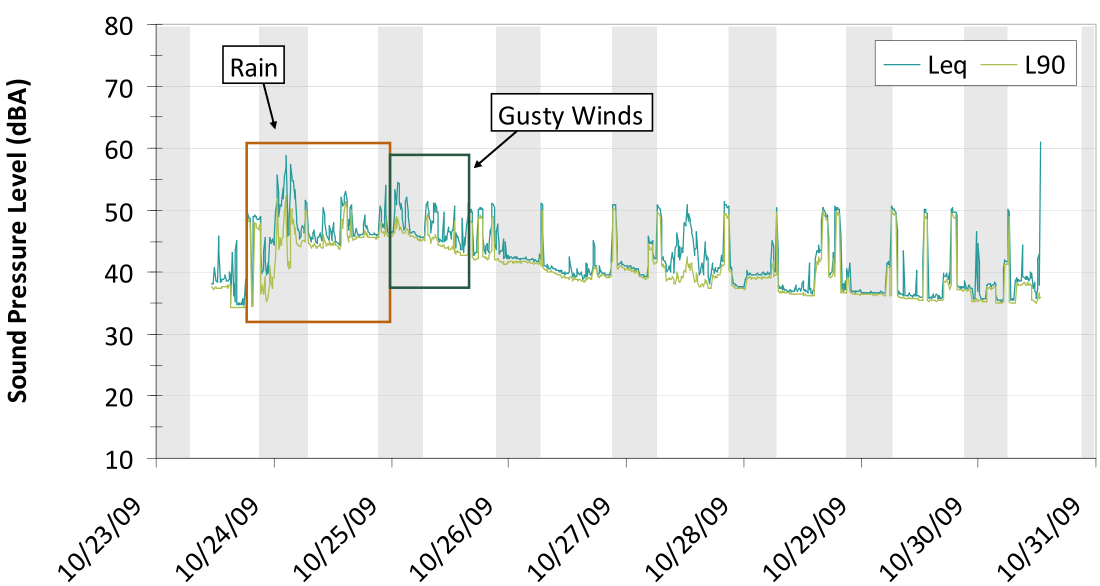


5.2.2 Monitoring Location 2 – Eden Road

Monitor 2 was located near the entrance to the Gebbie property on the eastern side of the project area on Eden Road (Figure 9). The monitoring results are shown in Figure 10.

Figure 9: Location of Monitor 2

Figure 10: Sound Pressure Levels (10-min, dBA) at Monitor 2

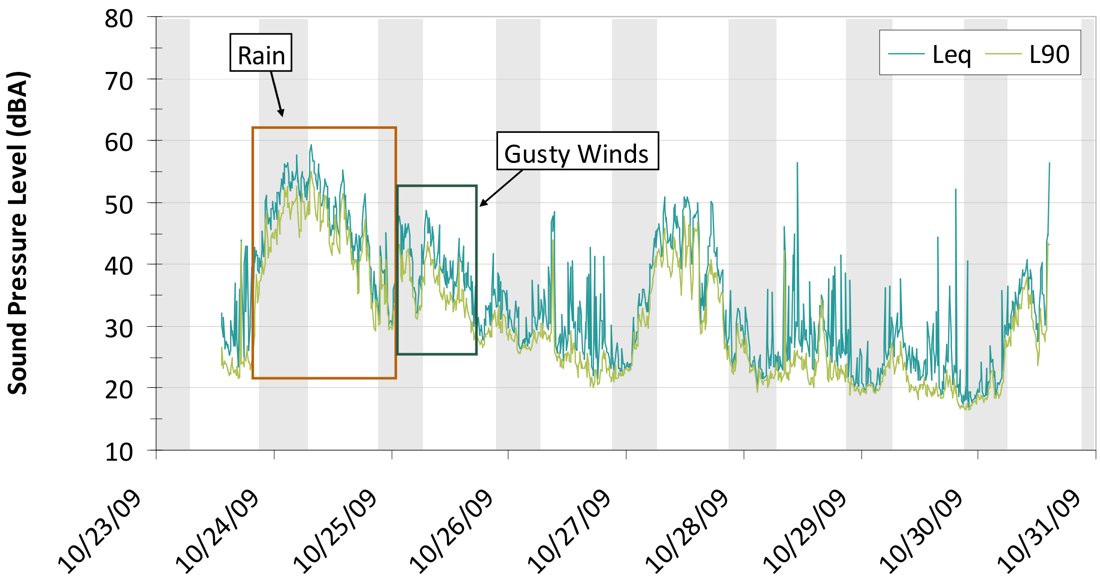


5.2.3 Monitoring Location 3 – Irish Farm Road, North of the Project

Monitor 3 was located at the Day residence at 606 Irish Farm Road on the northern side of the project area. It was placed next to a birch tree at the front of the property near the road (Figure 11). The monitoring results are shown in Figure 12.

Figure 11: Location of Monitor 3

Figure 12: Sound Pressure Levels (10-min, dBA) at Monitor 3

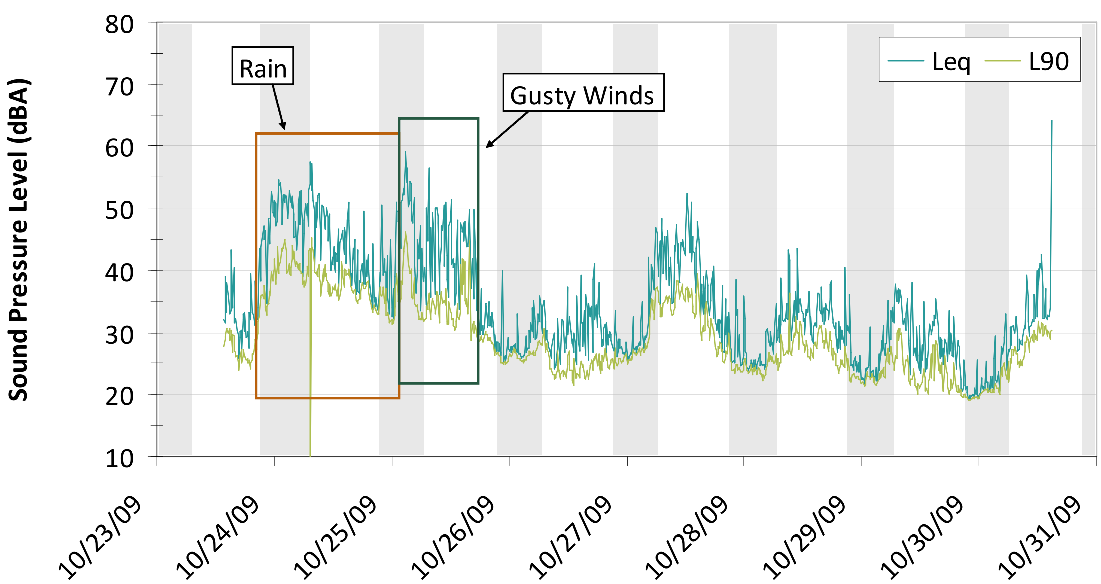


5.2.4 Monitoring Location 4 – Cheney Road, West of the Project

Monitor 4 was located at the Eddy residence on Cheney Road to the west of the project area. The monitor was placed in a field east of the house on the property (Figure 13). The ground weather monitoring station was also placed at this location approximately 50 feet east of the sound level monitor. The Monitor 4 results are shown in Figure 14.

Figure 13: Location of Monitor 4

Figure 14: Sound Pressure Levels (10-min, dBA) at Monitor 4

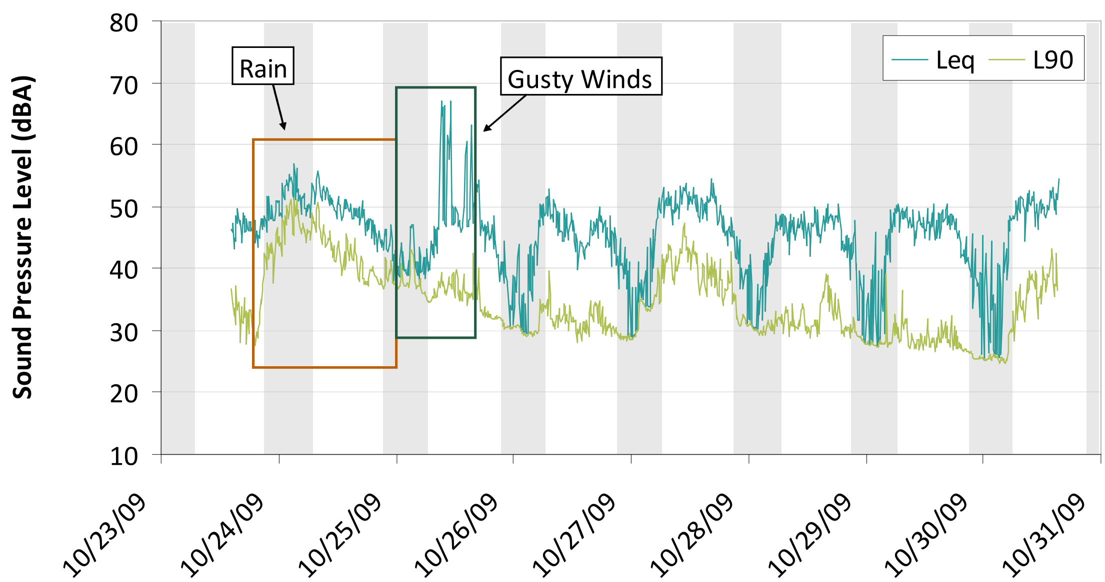


5.2.5 Monitoring Location 5 – VT 100, West of the Project

Monitor 5 was located at the Christiansen residence at 7020 VT 100 on the western side of the project area. It was placed next to the driveway approximately 185 feet from the house and 405 feet west of VT 100 (Figure 15). The results for Monitor 5 are shown in Figure 16.

Figure 15: Location of Monitor 5

Figure 16: Sound Pressure Levels (10-min, dBA) at Monitor 5

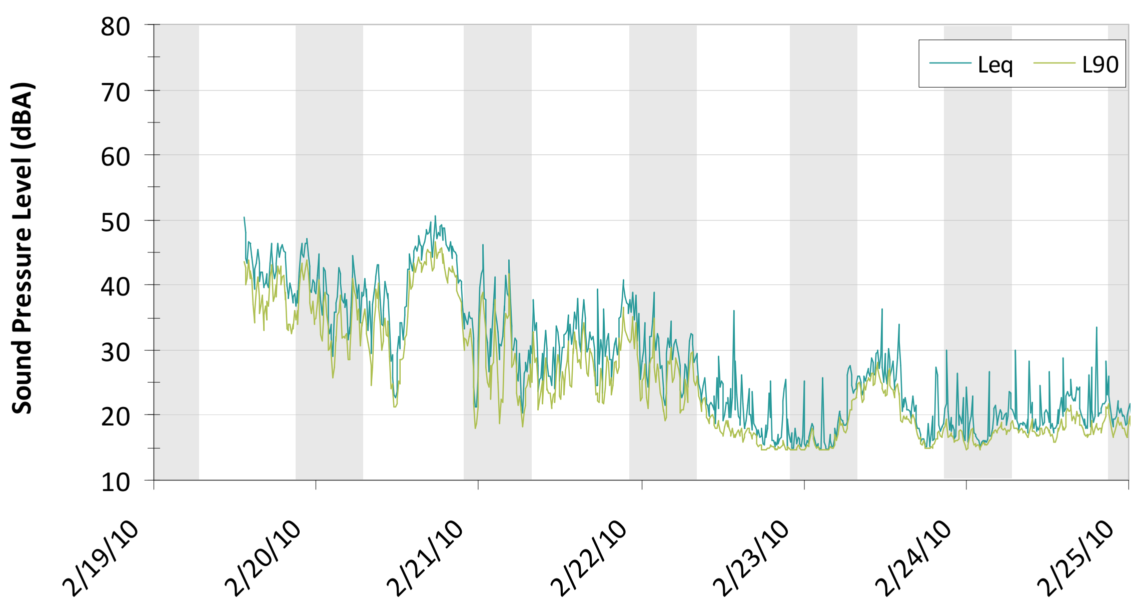


5.2.6 Monitoring Location 6 – Irish Hill Camp, North of the Project

Monitor 6 was located on the northern side of the project area at a hunting camp accessed by a 0.65-mile path running southwest from Irish Hill Road. It was placed approximately 100 feet from the structure (Figure 17). The results for Monitor 6 are shown in Figure 18. During the monitoring pick-up, construction- or generator-related noise was heard from another camp in the vicinity.

Figure 17: Location of Monitor 6

Figure 18: Sound Pressure Levels (10-min, dBA) at Monitor 6



5.2.7 Overall Sound Monitoring Results

The overall results are summarized in Table 4. Four different levels are shown: the Leq, L90, L50, and L10. As mentioned in the Section 3.5, the Leq is the equivalent average sound level. This measure weights louder sounds more than quieter sounds because it is based on a logarithmic average. The L90, L50, and L10 are the sound levels exceeded 90%, 50%, and 10% of the time, respectively.

Table 4: Background Monitoring Results Summary (dBA)

Monitor	Daytime				Nighttime			
	Leq	L10	L50	L90	Leq	L10	L50	L90
1A	42	42	37	35	39	41	37	35
1B	45	32	32	32	35	32	32	32
2	44	50	40	36	42	43	40	37
3	40	43	28	21	33	34	25	20
4	37	37	30	24	31	31	26	21
5	48	52	42	30	44	47	31	26
6	56	49	44	38	49	48	43	40

6.0 SOUND LEVELS PRODUCED BY WIND TURBINES

6.1 Standards Used to Measure Wind Turbine Sound Emissions

A manufacturer of a wind turbine must test its turbines using two international standards:

1. International Electrotechnical Commission standard IEC 61400-11:2002(E), "Wind Turbine Generator Systems – Part 11: Acoustic Noise Measurement Techniques"
2. International Electrotechnical Commission standard IEC 61400-14:2005(E), "Wind Turbine Generator Systems – Part 14: Declaration of Apparent Sound Power Level and Tonality Values"

These standards provide sound power emission levels from a turbine, by wind speed and frequency. They also provide a confidence interval.

6.2 Manufacturer Sound Emissions Estimates

The wind turbine manufacturer and model has not yet been determined for this project. At the current time, the Vestas V90 3MW and GE 2.5 xl wind turbines are being considered.

The Vestas V90 is a pitch regulated wind turbine with a rotor diameter of 90 meters and a hub height of 80 meters. The turbine operates at variable rotor speeds with electronic controls to help minimize sound emissions.

The GE 2.5 xl is a relatively new wind turbine from General Electric. Like the V90, it uses active pitch control and variable speed rotor. It has a 100 meter rotor diameter with a hub height of 85 meters.

Sound emissions from a wind turbine are measured as sound *power.* As noted in Section 3.3, this is different from the sound *pressure* that one measures on a sound level meter. Sound *power* is the acoustical energy emitted by an object, and sound *pressure* is the measured change in pressure caused by acoustic waves at an observer location.

The guaranteed maximum sound power from the V90 and GE 2.5 xl is 107 dBA and 106 dBA, respectively. This translates into an approximate sound pressure level of 56 and 55 dBA at 200 meters from the turbine base. The sound power by wind speed is shown in Figure 19 and the sound power by sound frequency is shown in Figure 20.

Figure 19: Sound Power of the V90 3 MW and GE 2.5 xl Wind Turbines by Wind Speed

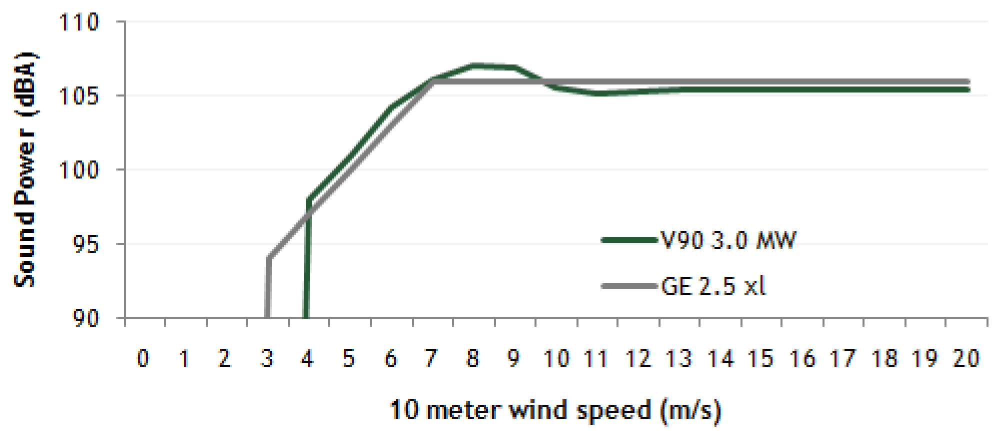
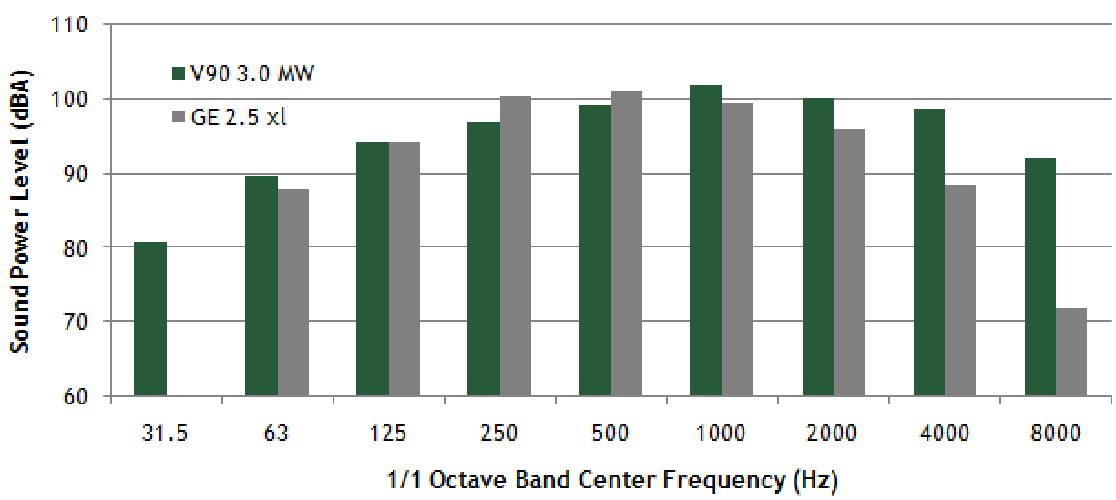


Figure 20: Sound Power of the V90 3 MW and GE 2.5 xl Wind Turbines by 1/1 Octave Band

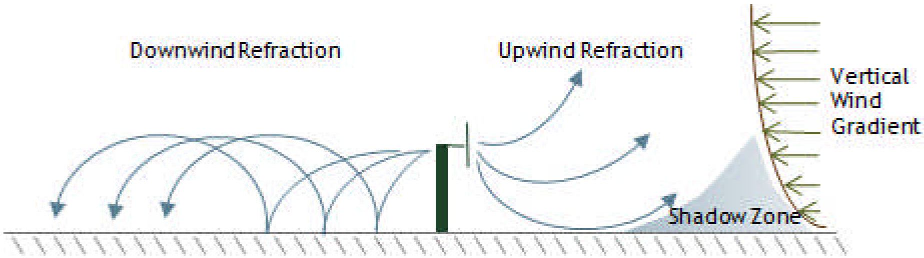


7.0 Sound From Wind Turbines

7.1 Meteorology

Meteorological conditions can significantly affect sound propagation. The two most important conditions to consider are wind shear and temperature lapse. Wind shear is the difference in wind speeds by elevation and temperature lapse rate is the temperature gradient by elevation. In conditions with high wind shear (large wind speed gradient), sound levels upwind from the source tend to decrease and sound levels downwind tend to increase due to the refraction, or bending, of the sound (Figure 21).

Figure 21: Schematic of the refraction of sound due to vertical wind gradient (wind shear)



With temperature lapse, when ground surface temperatures are higher than that aloft, sound will tend to refract upwards, leading to lower sound levels near the ground. The opposite is true when ground temperatures are lower than those aloft (an inversion condition).

The term "Stability Class" is used to describe how stable the atmosphere is. Unstable atmospheres can be caused by high winds and/or high solar radiation. This creates turbulence and tends to break up and dissipate sound energy. Highly stable atmospheres, which tend to occur on clear nights with low ground-level wind speeds, tends to minimize atmospheric turbulence and is generally more favorable to down-wind propagation.

In general terms, sound propagates best under stable conditions with a strong inversion. This occurs during the night and is characterized by low winds.[1] In those situations, sound levels from wind turbines would be at their lowest. Wind speeds under very stable conditions (Stability Class G) can be too low to generate electricity unless this coexists during a time with high wind shear. As a result, worst-case conditions for wind turbines tend to be under moderate nighttime inversions. As a result, this is the default condition for modeling wind turbine sound.

7.2 Masking

As mentioned above, sound levels from wind turbines are a function of wind speed. Background sound is also a function of wind speed, i.e., the stronger the winds, the louder the resulting background sound. This effect is amplified in areas covered by trees and other vegetation. The sound from a wind turbine can often be masked by wind noise at downwind receivers because the frequency spectrum from wind is very similar to the frequency spectra from a wind turbine.

It is important to note that while winds may be blowing at turbine height, there may be little to no wind at ground level. This can occur more frequently at night and can also occur on the leeward side of ridges where the ridge deflects the wind from the downwind valleys. These conditions can make wind turbine noise more noticeable at residences.

[1] The amount of propagation is highly dependent on surface conditions and the frequency of the sound. Under some circumstances highly stable conditions can show lower sound levels.

7.3 Infrasound and Low Frequency Sound

Infrasound is sound pressure fluctuations at frequencies below about 20 Hz. Sound below this frequency is generally not audible. Low frequency sound is in the audible range of human hearing, that is, above 20 Hz, but below 100 to 200 Hz depending on the definition.

At very high sound levels, infrasound can cause health effects and rattle light-weight building partitions. However, modern wind turbines, with the hub upwind of the tower, do not create this level of infrasound. As a result, modeling of infrasound impacts is not necessary.

Low frequency sound is a component of the sound generated by wind turbines. As with infrasound, high levels of low frequency sound can induce rattling in light-weight partitions in buildings. The American National Standards Institute standard, ANSI S12.2, "Criteria for Evaluating Room Noise", recommends that levels be kept below 65 dB at 16 Hz, 65 dB at 31.5 Hz, and 70 dB at 70 Hz inside the building to prevent moderately perceptible vibration and rattles.

In wind turbines, low frequency sound is primarily generated by the generator and mechanical components. Much of the mechanical noise has been reduced in modern wind turbines through improved sound insulation at the hub. Low frequency sound can also be generated at higher wind speeds when the inflow air is very turbulent. However, at these wind speeds, low frequency sound from the wind turbine blades is often masked by wind noise at the downwind receivers.

Finally, low frequency sound propagates better than higher frequency sound and tends to diffract more in the atmosphere under inversion conditions. Our modeling took into account nighttime inversions and differential atmospheric absorption of low and high frequency sound.

8.0 SOUND MODELING

8.1 Modeling Software

Modeling was completed for the project using Cadna A acoustical modeling software. Made by Datakustik GmbH, Cadna A is an internationally accepted acoustical model, used by many other noise control professionals in the United States and abroad. The software has a high level of reliability and follows methods specified by the International Standards Organization in their ISO 9613-2 standard, "Acoustics – Attenuation of sound during propagation outdoors, Part 2: General Method of Calculation." The ISO standard states,

> "This part of ISO 9613 specifies an engineering method for calculating the attenuation of sound during propagation outdoors in order to predict the levels of environmental noise at a distance from a variety of sources. The method predicts the equivalent continuous A-weighted sound pressure level … under meteorological conditions favorable to propagation from sources of known sound emissions. These conditions are for downwind propagation … or, equivalently, propagation under a well-developed moderate ground-based temperature inversion, such as commonly occurs at night."

The model takes into account source sound power levels, surface reflection and absorption, atmospheric absorption, geometric divergence, meteorological conditions, walls, barriers, berms, and terrain.

For this study, we modeled the sound propagation in accordance with ISO 9613-2 with spectral ground attenuation and non-porous ground (G=0), which has been found to yield the most accurate yet conservative results using standard modeling parameters.[1],[2] As an additional measure, we added 1 to 2 dB to the manufacturer's nominal sound power to get a guaranteed maximum sound power. These modeling parameters will tend to over-estimate the resulting sound levels from wind turbines.

We also used a second modeling methodology that takes into account the frequency of the varying meteorological conditions over the year. This is described further in Section 8.3.

8.2 Modeling Results – ISO 9613-2 with No Adjustments

As mentioned in the project description, two turbine scenarios are modeled – 20 GE 2.5 xl and 21 Vestas V90 3.0 MW. The modeling parameters used are described in Section 8.1 and detailed in the Appendix.

The results of the modeling are shown in Figure 22 and Figure 23. As shown in Table 5, the maximum modeled 1-hour sound level is well below the PSB precedent standard of 45 dBA at the closest residences to the project.

Table 5: Sound Monitoring Results at Selected Locations

Receiver	Approximate Distance to Nearest Turbine (miles)	20 GE 2.5xl (dBA)	21 V90 3.0 (dBA)
1064 Eden Road Closest residence to East	0.64	42	39
365 Bayley Hazen Road (Nelson residence)	0.89	42	38
Albany Town Clerk Office (Albany)	2.56	27	22
6777 VT 100 Closest home to west	1.04	35	31
606 Farm Road (Day Residence)	0.66	42	39

[1] Duncan, E., and Kaliski, K., "Improving Sound Propagation Modeling for Wind Power Projects," Acoustics 08, 2008, Paris, France.

[2] Bowdler, D. et al, "Prediction and assessment of wind turbine noise – Agreement about relevant factors for noise assessment from wind energy projects," Acoustics Bulletin, Vol 34 no 2, 2009

Figure 22: Modeling Results – 20 GE 2.5 xl Turbines

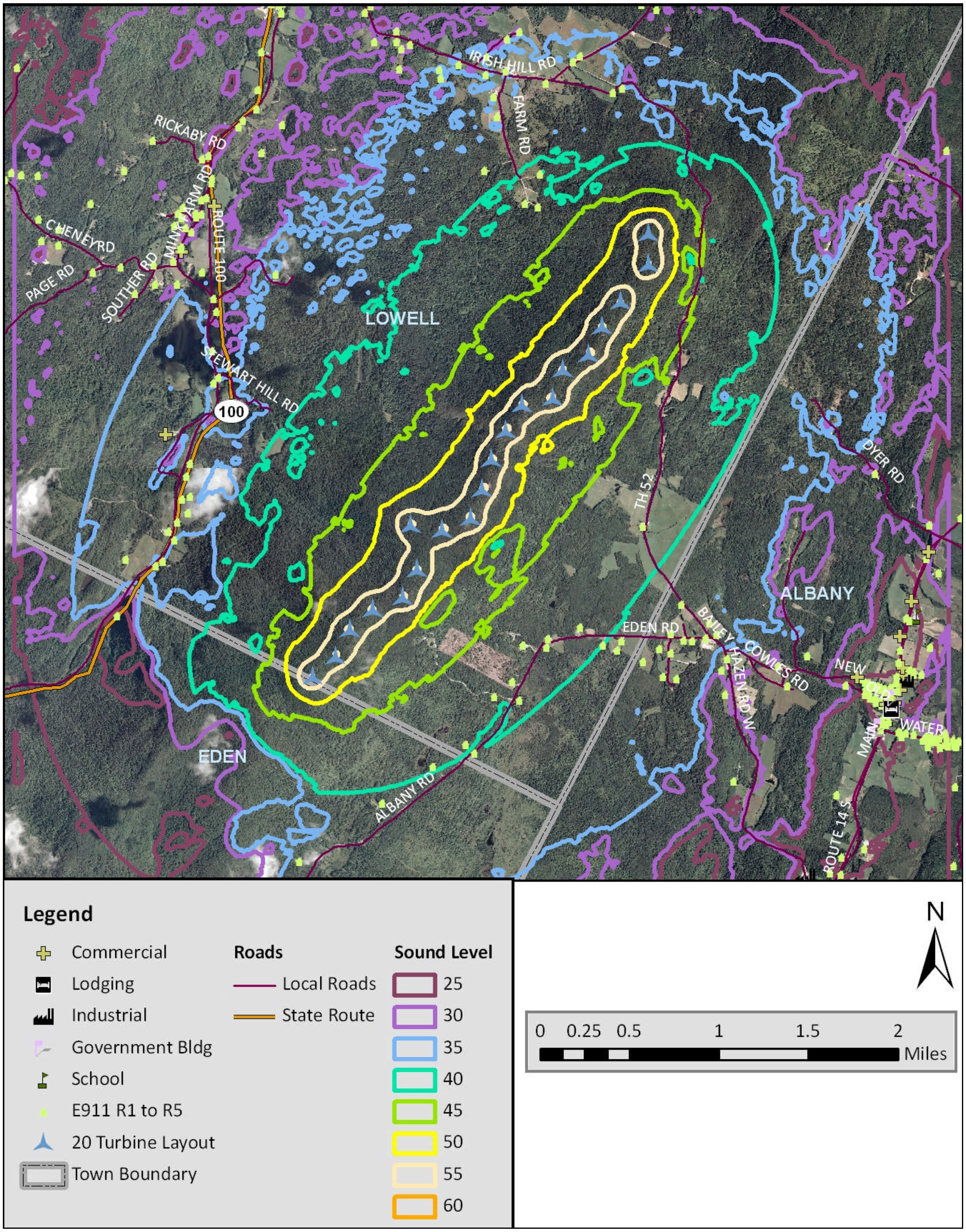
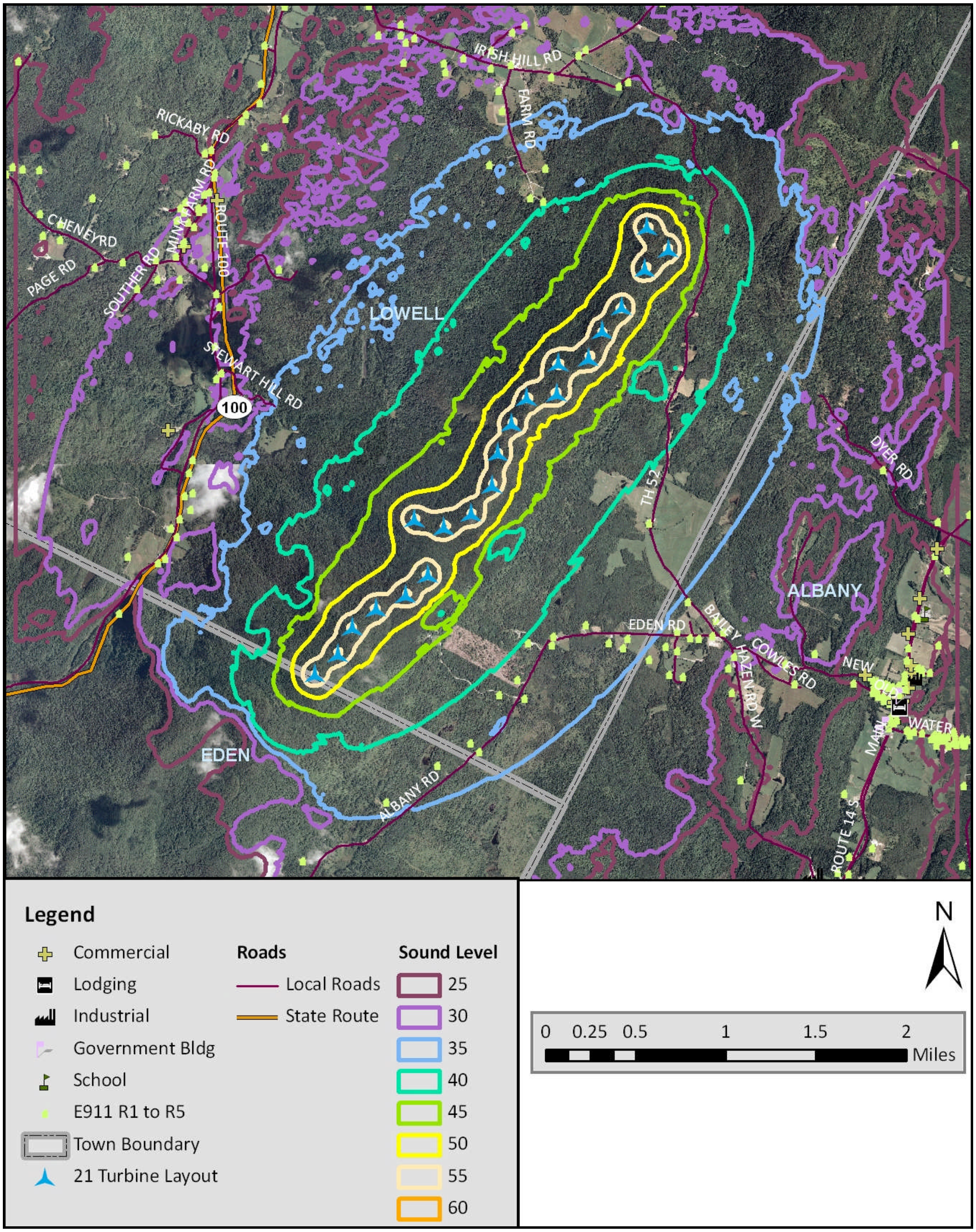


Figure 23: Modeling Results – 21 Vestas V90 3MW turbines



8.3 Modeling Using Hourly Meteorological Adjustments

As described in Section 4.2, the World Health Organization, in its “Guidelines for Community Noise., “ reviewed the latest research on the health effects of noise and recommended 45 dBA averaged over an eight hour night and a 60 dBA maximum, measured outside the bedroom window, to protect against sleep disturbance. In October 2009, the World Health Organization for Europe updated the 2000 review of the scientific literature, and found a no-adverse-effect noise level of 40 dB Lnight, outside, which is the A-weighted *annual average* nighttime sound level

In Section 8.2, we modeled the maximum one-hour sound level from the proposed wind farm. This is based on a worst-case meteorology of a moderate nighttime inversion, or equivalently, winds blowing from each source to each receiver. In reality, only one wind direction occurs at a time, and winds are not such that they are always generating the highest sound output from the turbines. As a result, the eight-hour and annual average nighttime sound level will tend to be less than the one maximum level.

To model the maximum eight-hour and annual average nighttime sound level, we undergo the following procedure:

1. 8760 hours of meteorological data is obtained from the project meteorological tower. The data includes wind speed at two or more heights, wind direction, the standard deviation of wind direction, and temperature.
2. Cloud cover is obtained from the closest National Weather Service station, the Barre/Montpelier Airport, about 50 miles to the south.
3. Atmospheric stability is calculated for each hour. Stability is important for calculating sound propagation. The “stability class” is calculated following the procedure in the U.S. EPA’s “On-site meteorological program guidance for regulatory modeling applications.” Stability Class ranges from A to G, with Class A being a high unstable atmosphere and Class G being very stable. Stability Class is a function of wind speed, cloud cover, solar angle, daytime/nighttime, and ceiling height.
4. A sound propagation model is run for 64 different combinations of wind speed, wind direction, and atmospheric stability, using the Cadna A model and meteorological adjustments from Concawe’s “The propagation of noise from petroleum and petrochemical complexes to neighboring communities.”
5. A raw unadjusted sound level is obtained for each receiver for each hour by matching each hour’s wind speed, wind direction, and stability class to those used in the model runs.
6. The hourly sound level at each receiver is adjusted to account for the different sound power by hub height wind speed using the manufacturer sound curves. No sound is generated below cut-in and above cut-out wind speeds.
7. The sound level is further adjusted to account for a random normalized distribution about the mean sound power level.
8. Sound levels during each night are calculated and averaged for the entire year.

The results of the modeling are shown in Table 6 and Table 7. Under all circumstances, the modeling results show that WHO guidelines are met. This methodology gives a higher one-hour maximum sound level than the unadjusted method from the previous section because this method uses more conservative assumptions.

Because we are evaluating hourly meteorological data, this analysis allows us to evaluate the distribution of sound levels that a residence would experience from the wind turbines over the course of the year. As Figure 24 show for the V90 3.0 MW wind turbine, the median sound level from the project at the closest residence is 28 dBA.

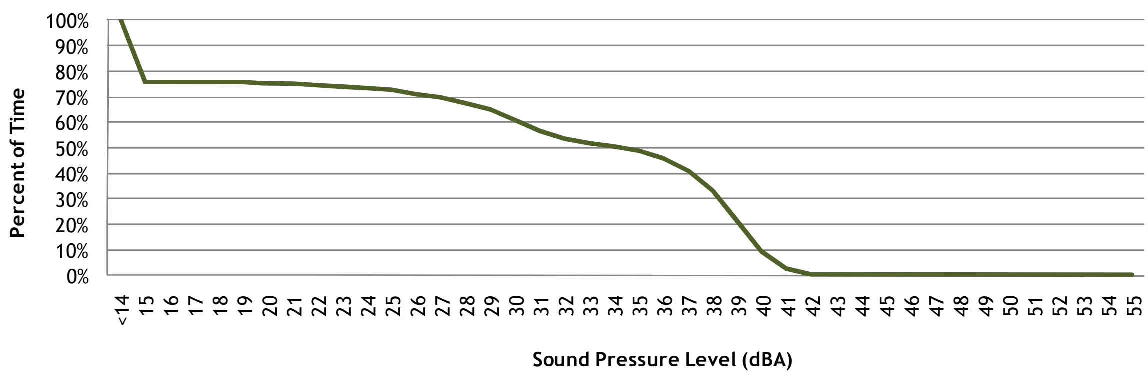
Table 6: Modeling Results Using Hourly Meteorological Data (In dBA) – 20 GE 2.5 xl Turbines

Receiver	Annual average sound level (Leq annual)	Maximum sound level 1 hour (Lmax)	Average nighttime sound level (L night, outside)	Maximum nighttime sound level (Ln 8hr max)
1064 Eden Road	37	45	38	43
365 Bayley Hazen	37	44	37	42
6777 VT 100	29	37	37	35
606 Farm Road	35	44	35	42

Table 7: Modeling Results Using Hourly Meteorological Data (in dBA) – 21 Vestas V90 3.0 MW

Receiver	Annual average sound level (Leq annual)	Maximum sound level 1 hour (Lmax)	Average nighttime sound level (L night, outside)	Maximum nighttime sound level (Ln 8hr max)
1064 Eden Road	35	41	35	40
365 Bayley Hazen	34	40	34	39
6777 VT 100	25	34	25	32
606 Farm Road	32	41	32	39

Figure 24: Cumulative Frequency Distribution – Closest residence east of the project – using V90 3.0 MW



8.4 Low Frequency Noise

As noted in Section 7.3, the ANSI S12.2 criteria for noise induced vibration and rattles inside buildings is 65 dB at 65 Hz, 65 dB at 31.5 Hz, and 70 dB at 63 Hz. The modeling results show the worst case sound levels are at the residence to the north of the project. At this location, the modeled low frequency sound levels do not exceed the ANSI criteria at 31.5 and 63 Hz.

As shown, there is no data at 16 Hz for both turbines and at 31.5 Hz for the GE. However, based on the spectral shape for similar turbines, we do not expect that these turbines will exceed the ANSI standard at any frequency.

Table 8: Modeled Low Frequency Sound at the Nearest Residence (in dB)

Receiver	16 Hz	31.5 Hz	63 Hz
GE 2.5 xl	No data	No data	53
Vestas V90 3 MW	No data	46	49

9.0 CONSTRUCTION IMPACTS AND OTHER NOISE SOURCES

9.1 Substations

Three substations will be affected by this project:

1) A new step-up transformer along the wind farm access road.
2) Changes to the substations in Lowell along VT 100.
3) Changes to a substation in Jay along Cross Road

To assess the impact of these changes, sound level monitoring and modeling was conducted.

9.1.1 Kingdom Community Wind Substation

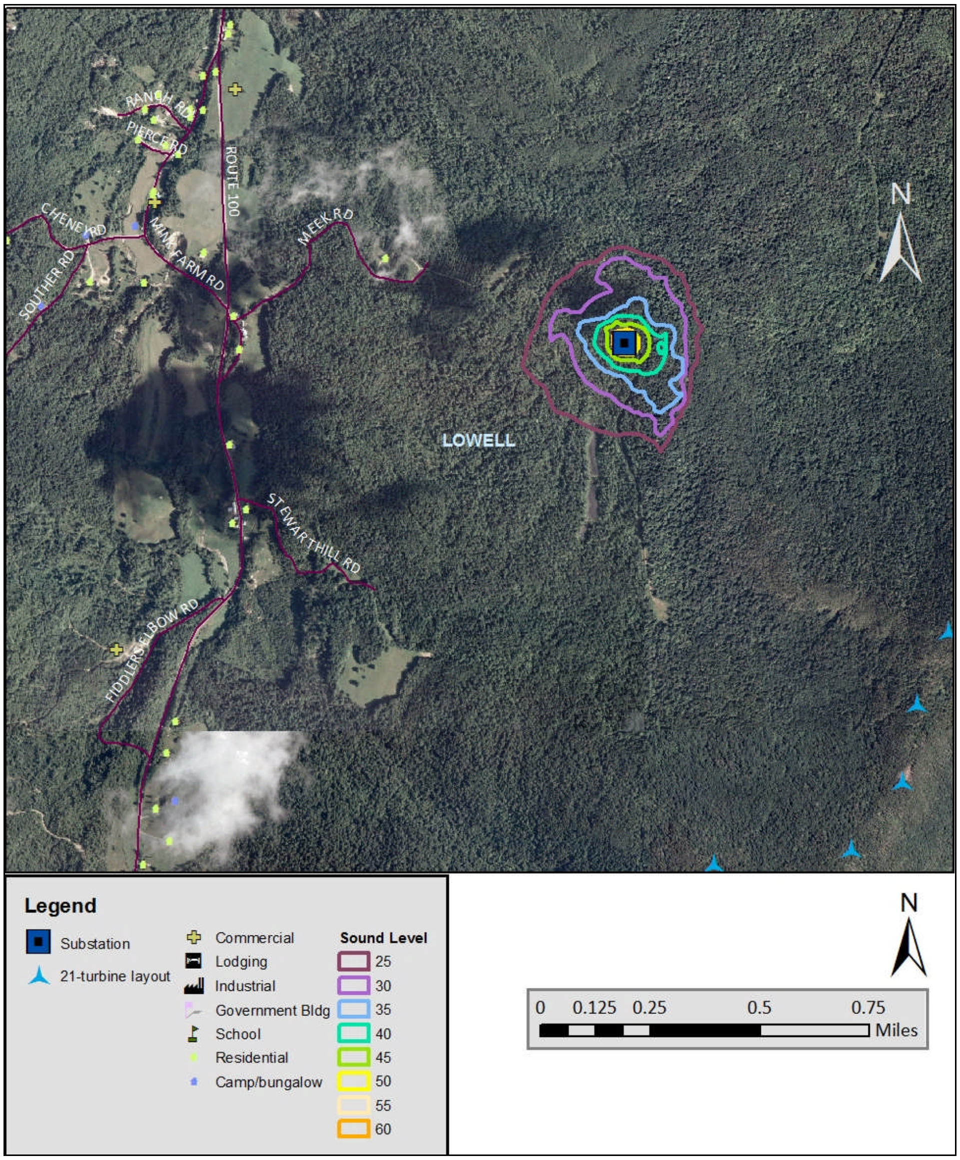
There will be a new step-up transformer for the project, which will be located along the access road to the project, about halfway between VT 100 and the turbine array (Figure 1). It is over 3,050 feet from the nearest participating residence, which is on Meek Road, and 4,700 feet to the nearest non-participating residence, which is on Stewart Road.

The transformer is designed to step up voltage from 34.5 kV to 46 kV. It is proposed to be rated at 250 kV BIL and a maximum power rating of 67 MVA. The NEMA TR-1 rating for the maximum sound pressure level is 71 dBA ONAN (fans off) and 74 dBA OFAF (fans on). Based on these sound pressure levels and similar sized transformers, the maximum sound power level is approximately 90 dBA ONAN and 93 dBA OFAF.

Sound levels from the transformer were modeled independently. As with the wind turbines, the modeling used the Cadna A software, implementing ISO 9613-2. Spectral ground attenuation was assumed, with a ground factor of 1, indicating soft ground. No attenuation due to vegetation was assumed, despite the dense forest surrounding the site.

The modeled sound level from the transformer at the nearest participating residence on Meek Road is 18 dBA. The modeled level at the nearest participating residence is 9 dBA. Both are below the lowest nighttime L90 of 20 dBA measured in the project area.

Figure 25: Sound Modeling Results for the Proposed Kingdom Community Wind Substation



9.1.2 Lowell Substations

Modifications will be made at the existing Lowell substations on VT 100. These are 0.3 miles north of the VT 58/VT 100 intersection, on the east side of VT 100, just south and across the street from the elementary school. The two substations at this location are labeled Lowell #5 and Irasburg #21, about 75 feet to the north of Lowell #5, and will be replaced by a single substation.

At Lowell #5, there are two transformers, a CVPS three-phase 46 kV/34.6 kV transformer, and three single-phase VEC 34.5 kV/12.47 kV transformers. Sound measurements were made at the substation on 13 April 2010, and found the sound power level of the CVPS transformer to be approximately 78 dBA

ONAN,[1] while the VEC transformers summed to 64 dBA ONAN.[2] The CVPS transformer has fans, but the fans were not operating during the measurements. The VEC transformers did not have cooling fans.

Transformer measurements were also made at the one single-phase transformer at Irasburg #21. This is a single-phase 34.5 kV/14.4 kV transformer. Measurements made on 13 April 2010 found a sound power level of 61 dBA ONAN. There are no fans on this unit.

Measurements of 1/3 octave band sound pressure levels were made at both substation fencelines between 10:00 am and 11:00 am on 13 April 2010. [3] There was considerable traffic on VT 100, but the CVPS transformer was clearly audible at each point along the Lowell #5 fence. The results of the monitoring are shown in Figure 26.

As part of this project, the all VEC transformers will be removed from the Lowell #5 and Irasburg #21 substations. The CVPS transformer will remain unchanged. At Irasburg #21, a new 34.5 kV/12.47 kV transformer will be installed. It will be rated at 7.5/9.375 MVA ONAN/OFAF. The NEMA TR-1 maximum sound pressure level is 67 dBA ONAN and 70 dBA OFAF. This translates into an approximate sound power level of 83 dBA ONAN and 86 dBA ONAF.

Using the same model described in Section 9.1.1, the sound level for the Lowell substations were estimated for the existing and proposed scenarios. The results, shown in Figure 27, indicate sound levels increasing at all locations with the proposed project. However, the highest sound levels remain at or below 31 dBA, This is equivalent to the nighttime L50 at long-term monitoring station 5, which was situated along VT 100, about 5 miles south of VT 58.

While the modeling results show relatively low sound levels, the applicant should consider a guarantee on the transformer of 5 dB below the NEMA TR1 standard given the proximity of the elementary school.

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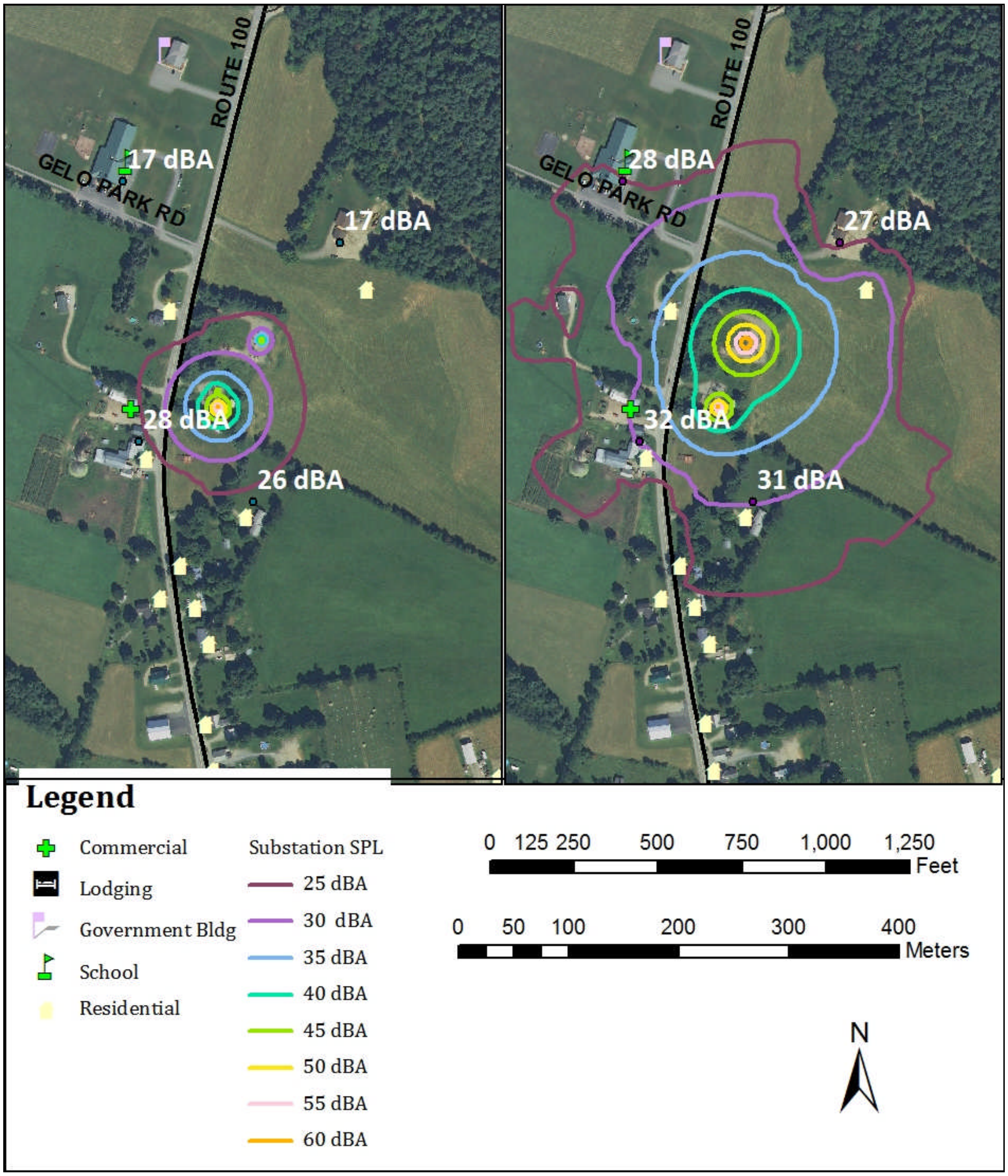
[1] We could not gain access to the CVPS portion of the substation. Sound power levels were estimated using measurements at the fence nearest to the transformer.

[2] Sound power was measured using the IEC 60076-10, “Power Transformers – Part 10: Determination of sound levels”, 2001

[3] Each point was monitored for two-minutes or more.

Figure 26: Preconstruction Sound Monitoring at the Lowell #5 and Irasburg #21 Substations (LA90)

Figure 27: Sound Modeling Results at the Lowell #5 and Irasburg #21 Substations – Existing and Proposed



9.1.3 Jay Substation

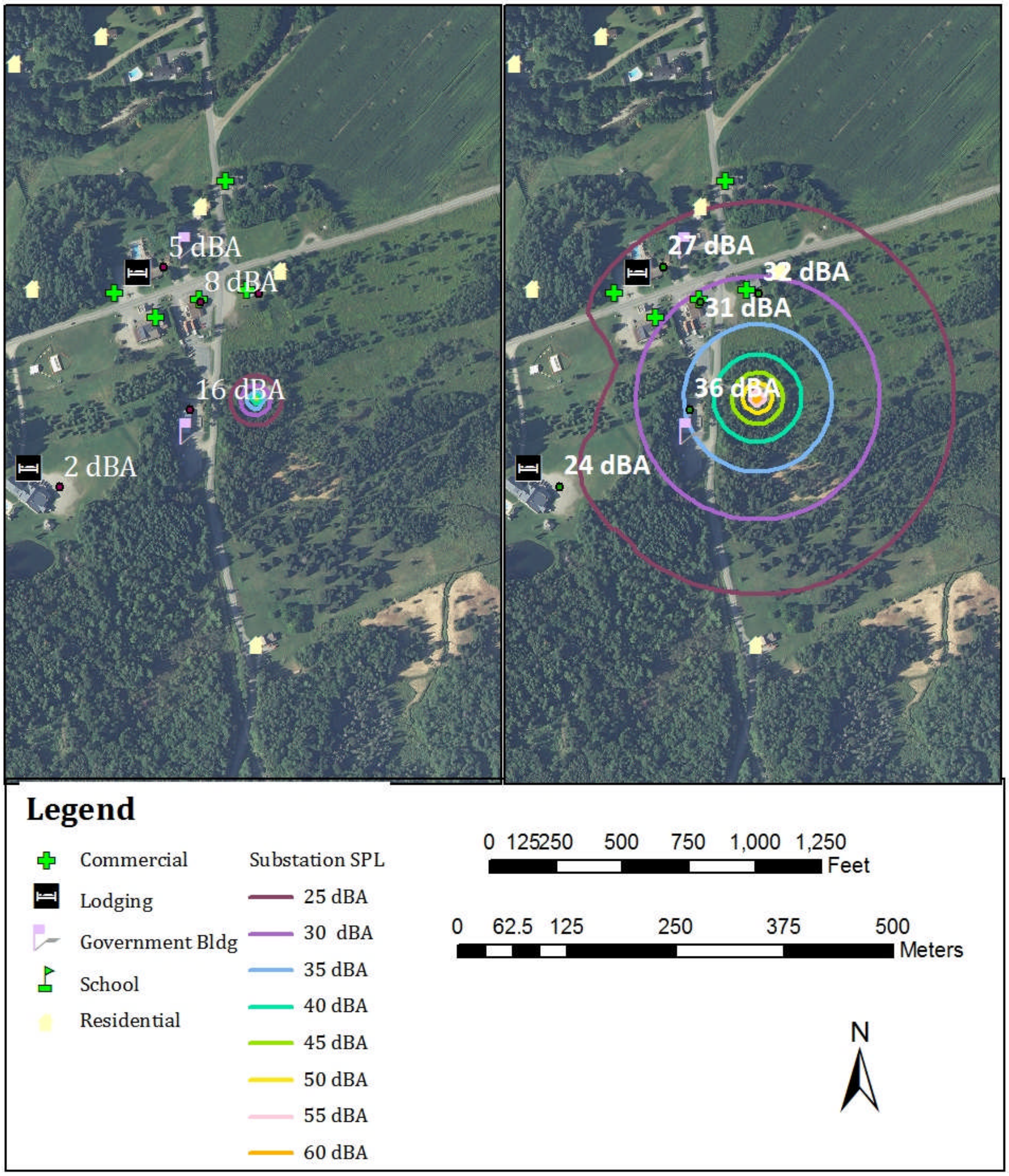
Modifications will be made to the Jay #17 substation on Cross Road in Jay, VT, just south of its intersection with VT 105 . This substation currently has three single-phase 34.5 kV/12.47 kV transformers. Monitoring conducted on 13 April 2010, according to IEC 60076-10 standards, indicate that each unit has a sound power level of 62 dBA. Fenceline monitoring results are shown in Figure 28.

The existing transformers are to be replaced with a 46 kV/12.47 kV transformer, similar to what is specified for the new Lowell substation. Modeling results of the new substation, indicate increases in sound levels with the larger transformer (with cooling fans on) (Figure 29). The nearest residence would have modeled levels of 32 dBA, while the Inns to the north and west would have levels of 27 dBA and 24 dBA, respectively.

While the modeling results show relatively low sound levels, the applicant should consider a guarantee on the transformer of 5 dB below the NEMA TR1 standard given the proximity of lodging facilities.

Figure 28: Preconstruction Sound Monitoring at the Jay #17 Substation (LA90)

Figure 29: Sound Modeling Results at the Jay #17 Substations – Existing and Proposed



9.2 Construction Impacts

Turbine construction will be primarily at the turbine sites. While there may be activity closer to residences for road construction and utility work, such work have a relatively short duration.

Equipment used for construction will vary. Some of the louder pieces of equipment are shown in Table 9 along with the approximate maximum sound pressure levels at 50 feet (15.2 m) and 2,600 feet (1,600 m).

Table 9: Maximum Sound Levels from Various Types of Construction Equipment Assuming No Attenuation from Trees or Terrain

EQUIPMENT	MAXIMUM SOUND PRESSURE LEVEL AT 2,600 FEET (dBA)[10]
M-250 Liftcrane	34
2250 S3 Liftcrane	30
Excavator	37
Dump truck being loaded	42
Dump truck at 25 mph accelerating	29
Tractor trailer at 25 mph accelerating	34
Concrete truck	33
Bulldozer	37
Rock drill	44
Loader	29
Backhoe	29
Wood chipper	51

Major construction work, such as clearing for the access roads and any drilling and blasting, will occur during the day. Some construction activity such extended concrete pours, blade lifts, and minor construction work may extend earlier or later.

Work on the turbine sites will be at least ½ mile from the nearest residence. Due to the distances between residences and construction locations, the time-of-day restrictions on drilling and blasting, and the limited duration of construction, construction noise will not create an undue adverse impact.

9.3 Other Noise Sources

There will be several minor noise sources at the site. These include:

1. Transformers –Small transformers will be built at the base of each transformer. These are not expected to be audible outside the property line.
2. Transmission lines – The transmission lines associated with the project are 34.5 and 46 kV. The voltage of these lines is too low to generate any significant corona noise and will likely be inaudible next to the lines.

[10] Assumes hard ground around construction site, and ISO 9614-2 propagation with no vegetation reduction. Actual sound levels will likely be lower given the prevalence of dense vegetation and soft ground around the site.

3. Maintenance and operations –The site will be accessed via a pickup truck or off-road vehicle. This level of increased traffic will not create any adverse sound impacts. There is also a possibility for cranes to be used at the site occasionally for repairs and maintenance.

10.0 RECOMMENDATIONS

Based on the above analysis, we recommend the following:

1) Specify wind turbines with no tonality as determined through precedent limits or tonal audibility below 4 dB as determined through IEC 61400-11
2) If the chosen turbine has a sound power greater than 107 dBA, then modeling should be redone to assure conformance with the standard.
3) Provide neighbors with a site supervisor to call so as to resolve noise complaints promptly.
4) Limit drilling and blasting to normal business hours.
5) Consider transformers for the new Lowell and Jay #17 substations that are 5 dB below NEMA TR-1 standards, considering their proximity to an elementary school and lodging.

11.0 SUMMARY AND CONCLUSIONS

Wind turbines are proposed for a ridgeline in Lowell, Vermont. The project currently proposes using either 20 GE 2.5 xl turbines rated at 2.5 MW each or 21 Vestas V90 turbines rated at 3.0 MW each. However, another turbine model may be used.

This report evaluated the potential noise impacts of the project and concluded the following:

1) The Public Service Board precedent of 45 dBA as a 1-hour maximum level is more conservative than the WHO guideline of 45 dBA averaged over the night, the WHO Europe guideline of 40 dBA averaged over all nights of the year, and the EPA guideline of 55 dB Ldn. This project is designed to meet the 45 dBA precedent standard outside all residences.

2) With all residences greater than 3,200 feet from the nearest turbine, the distance between the project and residences exceed the Congressional Research Service, National Academy of Sciences, and BLM guidelines, outside of which noise is generally not an issue.

3) Two types of modeling were conducted using conservative assumptions. Both types of modeling showed that the PSB precedent of 45 dBA, the WHO eight-hour sleep disturbance guideline of 45 dBA averaged over the night, the 40 dBA annual nighttime average WHO Europe sleep disturbance guideline, and U.S. EPA 45 dB Ldn guideline will be met at all residences.

4) To meet a 45 dBA standard outside of each residence, the sound power level from each wind turbine (assuming 21 turbines) should be at or below 107 dBA at the maximum rated capacity. However, other combinations of sound power levels, wind turbine siting

and changing the number of wind turbines can also achieve the same result. If the final choice of wind turbine has a higher sound power level, then modeling should be redone to assure conformance with applicable standards.

5) The levels of low frequency sound will not create perceptible building vibration.

6) The sound levels from the turbines will not rise to a level that can create hearing damage or pose quality of life concerns with respect to sleep disturbance or speech interference.

7) Other than extended concrete pours and similar events, major construction will take place during normal business hours. Aside from road construction, these activities will take place well away from the nearest residence and thus will have a minimal impact on noise levels.

8) One substation will be built, and three will be modified or eliminated. The proposed substations all have modeled sound levels that are well below Board precedent levels. However, two substations that will have new transformers are close to either an elementary school or lodging. For these, the applicant should install transformers with a manufacturer guarantee of 5 dB below NEMA TR-1 standards, if found to be cost-effective.

9) Other sound sources include routine maintenance and transformers at the base of the turbines. The routine maintenance and transformers will not create significant noise.

As a result, the Kingdom Community Wind Project can be constructed in such a way as to have no impact to health and no undue adverse impact on aesthetics.

APPENDIX

20 GE 2.5 xl Turbine Scenario: Modeled Receiver Input Data and Results

20 GE 2.5 xl Scenario: Modeled Wind Turbine Input Data and Modeling Parameters

21 Vestas V90 3 MW Turbine Scenario: Modeled Receiver Input Data and Results

21 Vestas V90 3 MW Scenario: Modeled Wind Turbine Input Data and Modeling Parameters

Kingdom Community Wind Substation: Modeled Transformer Input Data and Modeling Parameters

Kingdom Community Wind Substation: Modeled Receiver Input Data and Results

Jay Substation: Modeled Receiver Input Data and Results

Jay Substation: Modeled Transformer Input Data and Modeling Parameters

Lowell Substation: Modeled Transformer Input Data and Modeling Parameters

Lowell Substation: Modeled Receiver Input Data and Results

20 GE 2.5 xl Turbine Scenario: Modeled Receiver Input Data and Results

Receiver	Modeled Sound Pressure Level (dBA)	Relative Height (m)	Coordinates (UTM NAD 83 Z18N)		Elevation (m)
			X (m)	Y (m)	
Stackpole-French Camp	41.5	4	507281	252749	567
Nelsons	41.6	4	507293	249450	456
Mygatt Camp	44.9	4	507589	251038	531
Irish Farm Road	42.3	4	506344	252319	533
Gebbie Camp	47.2	4	505353	248444	587
Corrow Camp	39.1	4	504888	246953	518
1135000	23	4	502568	248652	442
196675	37.7	4	507541	248316	455
196662	23.9	4	509618	248159	299
196655	29.5	4	509110	248023	320
196654	33.8	4	508048	248263	420
196651	29.5	4	509430	247895	304
196644	37.3	4	507888	248584	437
196643	26.9	4	509633	248076	299
196637	37.4	4	507472	248104	459
196628	29.3	4	509484	247851	301
196627	33.6	4	508643	248154	349
196626	28.3	4	509583	247568	287
196621	30.1	4	509520	247925	304
196618	27.2	4	509392	248020	309
196615	23.8	4	509603	248340	299
196604	28.8	4	509295	247985	309
196603	29.6	4	509514	247866	301
196602	22.3	4	508883	245949	287
196595	37.1	4	507855	248449	440
196593	27.3	4	509352	248013	309
196589	37.4	4	507731	248424	445
196587	33.4	4	508586	248019	367
196581	22.8	4	509028	247042	293
196579	27.8	4	509470	247674	292
196573	29.9	4	509515	247888	302
196571	28	4	509389	248005	309
196566	26.5	4	509425	247631	289
196562	25.2	4	508974	246339	291
196554	28.3	4	509611	247563	285
196552	27.4	4	509328	248018	309
196540	30.9	4	508357	247139	359
196539	27.3	4	509442	247716	295
196530	27	4	509566	248054	303
196527	38.3	4	507287	248241	476
196526	37.6	4	507654	248433	449
196520	29.5	4	509463	247968	306
196519	28.7	4	509652	247597	282
196513	28.2	4	509548	248014	304
196497	23.7	4	509586	248230	300

20 GE 2.5 xl Turbine Scenario: Modeled Receiver Input Data and Results

196494	29	4	509436	247848	302
196489	30.3	4	509562	247916	301
196487	38.1	4	507437	248352	461
196480	26.8	4	509288	248050	311
196477	28	4	509517	248008	305
196475	28.7	4	509423	247990	308
196469	30.1	4	509571	247863	299
196460	32.1	4	508505	248200	359
196458	22	4	508738	246248	313
196452	27.2	4	509438	247657	291
196449	22.1	4	508744	246302	311
196446	26.7	4	509321	248047	309
196434	28.9	4	509588	247607	286
196427	31.1	4	509375	249928	327
196417	29.6	4	509527	247809	299
196412	24	4	509602	248469	298
196407	24.1	4	509660	248630	291
196386	23.5	4	509624	248188	299
196382	28.9	4	509322	247951	305
196381	23.2	4	509383	247590	286
196378	24	4	509683	248601	291
196372	28.5	4	509471	247756	297
196365	27	4	509595	248052	301
196356	29.9	4	509540	247843	300
196350	29.2	4	509376	247912	304
196343	28.8	4	509603	247989	299
196342	29	4	509524	247978	304
196339	29.4	4	509473	247858	301
196327	27.4	4	509287	247940	306
196317	30.2	4	509549	247869	301
196312	28.8	4	509604	247602	285
196310	22	4	509072	246476	298
196300	38.1	4	507537	248488	454
196287	28.2	4	509423	248006	308
196281	36.9	4	507951	248482	430
196279	27.6	4	508028	247942	419
196269	28.8	4	509514	247732	296
196267	21.7	4	508750	246121	303
196254	31.3	4	507997	248160	432
196250	27.9	4	509333	247910	303
196248	25.5	4	509668	248134	297
196245	24.5	4	509215	248103	317
196244	29.1	4	509573	247974	301
196242	37	4	507590	248083	464
196224	25.8	4	509572	248101	302
196222	24.1	4	509706	248783	287
196221	28.6	4	509462	247993	307
196219	28.3	4	509380	247870	303
196218	22.6	4	509067	246327	287

20 GE 2.5 xl Turbine Scenario: Modeled Receiver Input Data and Results

196207	24.2	4	509654	248178	297
196205	29	4	509465	247793	299
196195	24.7	4	509629	248122	300
196193	27.2	4	509444	247679	292
196189	25.2	4	509256	248083	314
196188	30.1	4	509544	247888	302
196187	38.3	4	507638	248754	449
196185	28.1	4	509594	248015	301
196181	28.3	4	509501	247702	294
196179	21.6	4	509278	246556	289
196177	24.8	4	509692	248164	295
196174	30	4	509559	247941	302
196172	27.3	4	509364	248025	309
196171	34.3	4	508767	248287	371
166495	25.2	4	502216	256507	338
166486	36.6	4	503002	250280	406
166485	33.7	4	503441	252335	324
166484	27.7	4	503206	252165	318
166480	29	4	503969	255483	299
166476	17.5	4	502191	255423	305
166475	27.4	4	504240	256387	310
166474	27.4	4	503851	255624	288
166473	27.4	4	503636	255692	280
166470	41.8	4	506113	248061	489
166469	17.7	4	503114	255954	269
166465	22.3	4	504099	256229	313
166461	29.7	4	504275	255279	305
166460	25.8	4	503132	256528	277
166458	39.7	4	505778	247417	489
166456	28.9	4	504137	255574	305
166453	29.8	4	504822	255467	332
166452	29.7	4	504015	255132	287
166448	30.7	4	505994	255376	409
166446	28.3	4	503708	255673	277
166445	27.5	4	504214	256356	308
166433	28.2	4	504121	255938	304
166432	34.3	4	502914	251670	342
166426	27	4	507195	256516	425
166423	35.5	4	503339	249586	393
166421	25.6	4	504049	253061	306
166420	27.8	4	503691	255449	286
166419	42.4	4	506244	248328	484
166417	28.9	4	503674	255376	291
166414	32	4	507465	254702	449
166413	28.7	4	504103	255669	306
166408	26.9	4	503868	255246	286
166407	30.8	4	504073	254626	294
166401	31.4	4	507411	254090	452
166398	31.8	4	504036	254148	294

20 GE 2.5 xl Turbine Scenario: Modeled Receiver Input Data and Results

166397	31.8	4	504024	254128	294
166395	40.3	4	505697	247493	500
166394	20.1	4	507571	256096	429
166393	31.7	4	504084	254198	294
166391	31.8	4	504057	254150	294
166390	32.8	4	503332	252752	317
166386	26.7	4	504096	255446	300
166385	30.4	4	504563	255064	307
166384	32.5	4	504767	254224	324
166383	28.3	4	503635	255663	283
166381	39.4	4	507060	248342	476
166380	23.2	4	503617	255725	277
166378	33.2	4	507866	254220	494
166377	30.1	4	505880	255233	398
166376	25	4	506473	255594	426
166375	31.4	4	504577	254604	314
166373	31.5	4	504090	254308	294
166369	26.6	4	504177	256309	304
166367	26.8	4	504198	254385	306
166366	28.5	4	507705	256064	436
166363	34.5	4	505418	253674	394
166361	29.2	4	503537	255123	311
166358	29.6	4	504102	254777	294
166357	28.4	4	503717	255648	274
166355	28.6	4	504120	255722	308
166354	17.4	4	502007	255229	301
166351	30.3	4	503636	254594	319
166344	24.2	4	503889	255512	292
166343	37.3	4	503222	249722	384
166339	32.1	4	504618	254353	319
166338	33.1	4	507411	254359	444
166336	32.1	4	504689	254368	320
166335	19.9	4	503308	256043	261
166332	30.4	4	503509	254482	338
166331	30.4	4	503566	254518	326
166330	33.5	4	507274	254135	440
166329	29.7	4	504084	254867	290
166328	31.5	4	504556	254568	314
166327	27.2	4	507283	256566	420
166325	30.3	4	503602	254581	321
166324	31.8	4	502040	252120	397
166320	31	4	504450	254747	304
166319	29.2	4	504586	255642	316
166318	26.6	4	503604	255700	282
166317	20.2	4	503782	255272	286
166316	29.7	4	504195	255211	289
166314	32.9	4	504845	254123	332
166313	31.1	4	505965	255228	403
166311	39.5	4	507100	248425	479

20 GE 2.5 xl Turbine Scenario: Modeled Receiver Input Data and Results

166309	24.6	4	503110	256276	263
166308	27.8	4	504058	256128	316
166304	17.6	4	503177	256042	259
166303	32.9	4	504791	254067	326
166301	32	4	504039	254062	298
166295	29.4	4	504102	254713	294
166294	26.8	4	503622	255278	294
166293	28.7	4	504134	255689	308
166292	31.1	4	505830	255178	391
166289	26.7	4	504258	255123	289
166288	19.5	4	503750	255617	274
166283	17.7	4	503084	255916	271
166282	29.4	4	505075	253903	356
166280	32.2	4	506179	253894	421
166277	27.3	4	503750	255526	279
166275	27.6	4	503931	256161	312
166274	30.2	4	504406	255076	296
166271	32.3	4	506070	253829	417
166270	33.7	4	504878	253801	345
166268	29.4	4	504082	254829	291
166267	34	4	505077	253801	364
166263	34.2	4	505195	253780	372
166262	32.4	4	503860	253711	303
166261	31.2	4	504586	254704	311
166260	35.5	4	505887	253669	419
166258	27.7	4	503580	255267	298
166256	27.2	4	503611	255683	283
166255	29.8	4	504105	255150	287
166254	29.8	4	504077	255121	287
166253	28.9	4	504130	255616	305
166252	27.6	4	507703	256676	439
166250	28.2	4	504062	255902	304
166245	27.6	4	503666	255524	281
166244	31.7	4	507278	255011	471
166243	36.1	4	506661	253627	439
166241	31.2	4	503956	254147	302
166240	32.6	4	505633	253598	409
166239	37.7	4	503148	249695	390
166238	35.2	4	505463	253550	406
166236	33.8	4	503862	252811	324
166235	29.5	4	504084	254815	292
166232	35.9	4	506723	253678	436
166230	35.3	4	505881	253511	425
166229	26.3	4	503842	255260	286
166228	28.3	4	503657	255684	279
166227	28.5	4	504263	255144	289
166225	25.6	4	504284	255092	293
166224	28.4	4	503681	255598	277
166219	28.9	4	504023	255521	299

20 GE 2.5 xl Turbine Scenario: Modeled Receiver Input Data and Results

166216	35.8	4	506056	253540	429
166215	28.2	4	504096	254994	287
166213	35.1	4	503079	249328	395
166212	34.5	4	502975	249134	401
166211	36.8	4	506415	253433	446
166205	30.5	4	505169	255258	358
166204	36.6	4	507103	253383	491
166201	32.9	4	503828	253374	315
166200	28.4	4	503655	255594	281
166198	26.5	4	503481	255873	273
166195	36.1	4	505947	253307	440
166193	27.2	4	503658	255098	299
166191	23.3	4	503915	255519	292
166189	29.5	4	503914	255176	284
166186	33.4	4	503817	253200	304
166185	25.9	4	503170	256687	270
166183	29.2	4	504397	255569	313
166178	33.4	4	503696	253096	304
166174	32.8	4	503655	253042	310
166170	32.3	4	502886	252918	373
166169	37.2	4	503026	249404	394
166167	37.5	4	505980	253130	457
166166	34.3	4	505289	253719	385
166163	30.3	4	503177	254310	369
166159	28.3	4	504076	255858	304
166154	25.6	4	503388	252786	314
166150	39	4	505866	252646	485
166149	28	4	503660	255567	280
166142	32.2	4	502630	252648	402
166139	33.6	4	503141	251962	324
166137	33.9	4	503421	252575	324
166135	34.6	4	505555	253586	405
166134	33.9	4	503415	252541	321
166133	42.1	4	506437	248445	479
166130	19.7	4	503515	255818	273
166128	30.7	4	505543	255274	379
166125	29.6	4	503322	252386	314
166124	36.4	4	502643	249154	417
166121	32.1	4	502326	252351	404
166119	20.8	4	503943	255549	292
166115	41.6	4	506232	252351	526
166111	30.7	4	506090	255374	405
166110	35	4	502912	249098	401
166109	30.7	4	506184	255392	404
166108	33.8	4	503157	252317	318
166107	41.8	4	506423	248367	479
166106	33.8	4	503108	252266	324
166104	29	4	503274	252265	314
166103	29.2	4	503321	252259	320

20 GE 2.5 xl Turbine Scenario: Modeled Receiver Input Data and Results

166102	25.6	4	503275	252234	315
166101	28.5	4	504167	255804	306
166100	33.9	4	503143	252226	321
166098	37.1	4	503103	249488	394
166096	33.9	4	503082	252152	324
166095	26.6	4	503232	252099	326
166093	29.1	4	504166	255500	304
166092	28.2	4	503682	255547	279
166091	32	4	502037	251978	399
166090	33.2	4	503139	251952	324
166089	26.8	4	504366	256752	304
166087	32.3	4	503144	251923	326
166083	34.1	4	502892	251804	339
166081	30.6	4	503551	254424	328
166078	41.2	4	506726	248545	470
166076	33.5	4	502599	251782	366
166073	34.8	4	503327	251738	343
166072	27.6	4	504107	255761	306
166071	33	4	502347	251735	374
166069	36.5	4	503991	251717	420
166068	27.1	4	503576	255749	279
166065	29	4	504076	255499	301
166064	29	4	504120	255527	304
166063	34.6	4	503105	251626	329
166062	18	4	505149	256647	326
166057	34.1	4	502725	251543	350
166056	34.9	4	503433	251502	339
166055	39.9	4	506931	248384	473
166054	34.7	4	503456	251383	341
166053	17.7	4	502601	255629	296
166052	40.4	4	506363	252617	515
166048	26.3	4	503608	255746	276
166046	34	4	503418	251030	340
166044	33.9	4	503074	251834	327
166043	29.5	4	504279	255365	309
166041	28.5	4	503682	255581	277
166039	35.5	4	503479	250795	350
166038	35.7	4	503430	250742	344
166035	37.5	4	503222	250016	393
166034	20.6	4	503776	255626	277
166033	37.4	4	503188	249902	389
166026	30.9	4	504525	254845	302
166025	25.4	4	502225	256545	338
166023	17.7	4	503246	256015	263
166019	28.6	4	504089	255730	305
166017	29.1	4	506620	255486	441
166015	23.2	4	507204	255308	470
166014	26.1	4	503200	256538	271
166010	28.1	4	503825	255578	284

20 GE 2.5 xl Turbine Scenario: Modeled Receiver Input Data and Results

166008	17.9	4	504689	256550	294
166007	28.2	4	504276	256011	309
166001	28.8	4	503676	255424	292
166000	27.3	4	504258	256436	309
165999	28.8	4	504107	255625	304
165998	28.4	4	503663	255618	279
165996	36.5	4	507023	253348	482
165988	28.1	4	504098	255992	306
165985	28.1	4	504800	255740	333
165981	28.6	4	503574	255287	298
165975	23.8	4	503843	255575	284
165972	28.8	4	504107	255625	304

20 GE 2.5 xl Scenario: Modeled Wind Turbine Input Data and Modeling Parameters

Wind Turbine	Sound Power Level (dBA)	Correction Factor (dBA)	Relative Height (m)	Coordinates (UTM NAD 83 Z18N)		Elevation (m)
				X (m)	Y (m)	
TSTATEPLNE_11-9-0900001	106	1.8	85	507340	252095	791
100002	106	1.8	85	507339	251819	785
100002	106	1.8	85	507091	251484	769
100002	106	1.8	85	506925	251264	816
100002	106	1.8	85	506803	251013	828
100002	106	1.8	85	506567	250875	800
100002	106	1.8	85	506477	250617	838
100002	106	1.8	85	506206	250561	869
100002	106	1.8	85	506054	250326	885
100002	106	1.8	85	505926	250066	861
100002	106	1.8	85	505847	249798	849
100002	106	1.8	85	505740	249542	850
100002	106	1.8	85	505487	249430	821
100002	106	1.8	85	505202	249474	792
100002	106	1.8	85	505260	249080	798
100002	106	1.8	85	505134	248827	824
100002	106	1.8	85	504863	248720	800
100002	106	1.8	85	504657	248542	843
100002	106	1.8	85	504530	248297	850
100002	106	1.8	85	504322	248118	857

Sound Power Levels

Turbine Model	Octave Band Frequency (Hz)									dBA
	31.5	*63*	*125*	*250*	*500*	*1000*	*2000*	*4000*	*8000*	
GE 2.5 xl		85.9	92.4	98.6	99.2	97.5	94.2	86.4	70	104.2

Modeling Parameters

Parameter	Setting
Ground Absorption	ISO 9613-2 Spectral, G=0
Atmospheric Absorption	Based on 10 Degrees Celsius, 70 % Relative Humidity
Reflections	None
Search Radius	2000 m from each source (1.24 miles)
Receiver Height	4 m (approximately 13 feet) for residences, 1.5 meters for grid
Contour Interval	5.0 m (16.4 ft) from USGS digital elevation model

21 Vestas V90 3 MW Turbine Scenario: Modeled Receiver Input Data and Results

Receiver	Modeled Sound Pressure Level (dBA)	Relative Height (m)	Coordinates (UTM NAD 83 Z18N)		Elevation (m)
			X (m)	Y (m)	
Stackpole-French Camp	38.3	4	507281	252749	567
Nelsons	38.1	4	507293	249450	456
Mygatt Camp	42.2	4	507589	251038	531
Irish Farm Road	39.5	4	506344	252319	533
Gebbie Camp	45.9	4	505353	248444	587
Corrow Camp	35.7	4	504888	246953	518
1135000	18.8	4	502568	248652	442
196675	34	4	507541	248316	455
196662	19.8	4	509618	248159	299
196655	25.5	4	509110	248023	320
196654	30.2	4	508048	248263	420
196651	25.4	4	509430	247895	304
196644	33.4	4	507888	248584	437
196643	22.8	4	509633	248076	299
196637	33.7	4	507472	248104	459
196628	25.3	4	509484	247851	301
196627	29.7	4	508643	248154	349
196626	24.2	4	509583	247568	287
196621	25.8	4	509520	247925	304
196618	23.2	4	509392	248020	309
196615	19.8	4	509603	248340	299
196604	24.7	4	509295	247985	309
196603	25.5	4	509514	247866	301
196602	18.1	4	508883	245949	287
196595	33.3	4	507855	248449	440
196593	23.3	4	509352	248013	309
196589	33.7	4	507731	248424	445
196587	29.6	4	508586	248019	367
196581	18.7	4	509028	247042	293
196579	23.1	4	509470	247674	292
196573	25.5	4	509515	247888	302
196571	23.2	4	509389	248005	309
196566	22.4	4	509425	247631	289
196562	21.1	4	508974	246339	291
196554	24.6	4	509611	247563	285
196552	23.3	4	509328	248018	309
196540	26.9	4	508357	247139	359
196539	23.2	4	509442	247716	295
196530	22.9	4	509566	248054	303
196527	34.6	4	507287	248241	476
196526	33.9	4	507654	248433	449
196520	25.1	4	509463	247968	306
196519	24.6	4	509652	247597	282
196513	23.9	4	509548	248014	304
196497	19.7	4	509586	248230	300

21 Vestas V90 3 MW Turbine Scenario: Modeled Receiver Input Data and Results

196494	25	4	509436	247848	302
196489	25.7	4	509562	247916	301
196487	34.4	4	507437	248352	461
196480	22.8	4	509288	248050	311
196477	23.9	4	509517	248008	305
196475	24.3	4	509423	247990	308
196469	25.8	4	509571	247863	299
196460	27.5	4	508505	248200	359
196458	17.9	4	508738	246248	313
196452	21.6	4	509438	247657	291
196449	18	4	508744	246302	311
196446	23.4	4	509321	248047	309
196434	24.8	4	509588	247607	286
196427	27.9	4	509375	249928	327
196417	25.1	4	509527	247809	299
196412	20	4	509602	248469	298
196407	20.1	4	509660	248630	291
196386	19.5	4	509624	248188	299
196382	24.8	4	509322	247951	305
196381	19.1	4	509383	247590	286
196378	20	4	509683	248601	291
196372	24.4	4	509471	247756	297
196365	23.5	4	509595	248052	301
196356	25.8	4	509540	247843	300
196350	25.1	4	509376	247912	304
196343	24.5	4	509603	247989	299
196342	24.9	4	509524	247978	304
196339	24.9	4	509473	247858	301
196327	23.3	4	509287	247940	306
196317	25.9	4	509549	247869	301
196312	24.7	4	509604	247602	285
196310	17.9	4	509072	246476	298
196300	34.5	4	507537	248488	454
196287	23.8	4	509423	248006	308
196281	33.2	4	507951	248482	430
196279	24.2	4	508028	247942	419
196269	24.3	4	509514	247732	296
196267	17.6	4	508750	246121	303
196254	27.8	4	507997	248160	432
196250	23.8	4	509333	247910	303
196248	21.5	4	509668	248134	297
196245	20.5	4	509215	248103	317
196244	24.8	4	509573	247974	301
196242	33.3	4	507590	248083	464
196224	21.7	4	509572	248101	302
196222	20.2	4	509706	248783	287
196221	24.2	4	509462	247993	307
196219	24.2	4	509380	247870	303
196218	18.3	4	509067	246327	287

21 Vestas V90 3 MW Turbine Scenario: Modeled Receiver Input Data and Results

196207	20.2	4	509654	248178	297
196205	24.5	4	509465	247793	299
196195	20.7	4	509629	248122	300
196193	22.4	4	509444	247679	292
196189	21.2	4	509256	248083	314
196188	25.8	4	509544	247888	302
196187	34.7	4	507638	248754	449
196185	23.7	4	509594	248015	301
196181	23.7	4	509501	247702	294
196179	17.5	4	509278	246556	289
196177	20.8	4	509692	248164	295
196174	25.9	4	509559	247941	302
196172	23.3	4	509364	248025	309
196171	30.4	4	508767	248287	371
166495	21.3	4	502216	256507	338
166486	32.8	4	503002	250280	406
166485	30	4	503441	252335	324
166484	23.8	4	503206	252165	318
166480	25.1	4	503969	255483	299
166476	13.6	4	502191	255423	305
166475	23.6	4	504240	256387	310
166474	23.4	4	503851	255624	288
166473	23.6	4	503636	255692	280
166470	38.5	4	506113	248061	489
166469	13.8	4	503114	255954	269
166465	18.2	4	504099	256229	313
166461	25.8	4	504275	255279	305
166460	21.9	4	503132	256528	277
166458	36.3	4	505778	247417	489
166456	25.1	4	504137	255574	305
166453	26	4	504822	255467	332
166452	25.9	4	504015	255132	287
166448	27	4	505994	255376	409
166446	24.5	4	503708	255673	277
166445	23.6	4	504214	256356	308
166433	24.4	4	504121	255938	304
166432	30.5	4	502914	251670	342
166426	23.5	4	507195	256516	425
166423	31.9	4	503339	249586	393
166421	21.7	4	504049	253061	306
166420	24	4	503691	255449	286
166419	39.2	4	506244	248328	484
166417	25	4	503674	255376	291
166414	28.6	4	507465	254702	449
166413	24.9	4	504103	255669	306
166408	23.2	4	503868	255246	286
166407	27	4	504073	254626	294
166401	28.2	4	507411	254090	452
166398	28	4	504036	254148	294

21 Vestas V90 3 MW Turbine Scenario: Modeled Receiver Input Data and Results

166397	28	4	504024	254128	294
166395	37	4	505697	247493	500
166394	16.4	4	507571	256096	429
166393	27.9	4	504084	254198	294
166391	28	4	504057	254150	294
166390	28.8	4	503332	252752	317
166386	23	4	504096	255446	300
166385	26.6	4	504563	255064	307
166384	28.8	4	504767	254224	324
166383	24.4	4	503635	255663	283
166381	35.7	4	507060	248342	476
166380	19.3	4	503617	255725	277
166378	29.7	4	507866	254220	494
166377	26.2	4	505880	255233	398
166376	21.9	4	506473	255594	426
166375	27.7	4	504577	254604	314
166373	27.7	4	504090	254308	294
166369	22.9	4	504177	256309	304
166367	22.8	4	504198	254385	306
166366	24.8	4	507705	256064	436
166363	31	4	505418	253674	394
166361	25.3	4	503537	255123	311
166358	25.5	4	504102	254777	294
166357	24.5	4	503717	255648	274
166355	24.8	4	504120	255722	308
166354	13.5	4	502007	255229	301
166351	26.5	4	503636	254594	319
166344	20.3	4	503889	255512	292
166343	33.1	4	503222	249722	384
166339	28.3	4	504618	254353	319
166338	29.8	4	507411	254359	444
166336	28.4	4	504689	254368	320
166335	17.1	4	503308	256043	261
166332	26.5	4	503509	254482	338
166331	26.5	4	503566	254518	326
166330	30.7	4	507274	254135	440
166329	25.3	4	504084	254867	290
166328	27.7	4	504556	254568	314
166327	23.5	4	507283	256566	420
166325	26.5	4	503602	254581	321
166324	27.8	4	502040	252120	397
166320	27.2	4	504450	254747	304
166319	25.4	4	504586	255642	316
166318	22.8	4	503604	255700	282
166317	16.3	4	503782	255272	286
166316	25.9	4	504195	255211	289
166314	29.2	4	504845	254123	332
166313	27.4	4	505965	255228	403
166311	35.9	4	507100	248425	479

21 Vestas V90 3 MW Turbine Scenario: Modeled Receiver Input Data and Results

166309	20.9	4	503110	256276	263
166308	23.9	4	504058	256128	316
166304	13.7	4	503177	256042	259
166303	29.3	4	504791	254067	326
166301	28.1	4	504039	254062	298
166295	25.3	4	504102	254713	294
166294	22.8	4	503622	255278	294
166293	24.9	4	504134	255689	308
166292	27.4	4	505830	255178	391
166289	21.1	4	504258	255123	289
166288	15.5	4	503750	255617	274
166283	13.8	4	503084	255916	271
166282	25.7	4	505075	253903	356
166280	28.8	4	506179	253894	421
166277	23.2	4	503750	255526	279
166275	23.8	4	503931	256161	312
166274	26.4	4	504406	255076	296
166271	28.8	4	506070	253829	417
166270	30.1	4	504878	253801	345
166268	25.3	4	504082	254829	291
166267	30.4	4	505077	253801	364
166263	30.6	4	505195	253780	372
166262	28.6	4	503860	253711	303
166261	27.5	4	504586	254704	311
166260	32	4	505887	253669	419
166258	23.9	4	503580	255267	298
166256	23.4	4	503611	255683	283
166255	25.9	4	504105	255150	287
166254	26	4	504077	255121	287
166253	25	4	504130	255616	305
166252	23.8	4	507703	256676	439
166250	24.4	4	504062	255902	304
166245	23.8	4	503666	255524	281
166244	28.1	4	507278	255011	471
166243	33.1	4	506661	253627	439
166241	27.5	4	503956	254147	302
166240	29.1	4	505633	253598	409
166239	34	4	503148	249695	390
166238	31.7	4	505463	253550	406
166236	30	4	503862	252811	324
166235	25.7	4	504084	254815	292
166232	32.8	4	506723	253678	436
166230	32.1	4	505881	253511	425
166229	22.7	4	503842	255260	286
166228	24.4	4	503657	255684	279
166227	24.8	4	504263	255144	289
166225	21.2	4	504284	255092	293
166224	24.6	4	503681	255598	277
166219	25.1	4	504023	255521	299

21 Vestas V90 3 MW Turbine Scenario: Modeled Receiver Input Data and Results

166216	32.6	4	506056	253540	429
166215	24.5	4	504096	254994	287
166213	31.4	4	503079	249328	395
166212	31.2	4	502975	249134	401
166211	33.7	4	506415	253433	446
166205	26.8	4	505169	255258	358
166204	33.7	4	507103	253383	491
166201	29.1	4	503828	253374	315
166200	24.5	4	503655	255594	281
166198	22.8	4	503481	255873	273
166195	33	4	505947	253307	440
166193	23.5	4	503658	255098	299
166191	19.2	4	503915	255519	292
166189	25.7	4	503914	255176	284
166186	29.6	4	503817	253200	304
166185	22.1	4	503170	256687	270
166183	25.4	4	504397	255569	313
166178	29.6	4	503696	253096	304
166174	29.1	4	503655	253042	310
166170	28.4	4	502886	252918	373
166169	32.9	4	503026	249404	394
166167	34.3	4	505980	253130	457
166166	30.7	4	505289	253719	385
166163	26.4	4	503177	254310	369
166159	24.5	4	504076	255858	304
166154	21.6	4	503388	252786	314
166150	36	4	505866	252646	485
166149	24.2	4	503660	255567	280
166142	28.3	4	502630	252648	402
166139	29.8	4	503141	251962	324
166137	30.1	4	503421	252575	324
166135	31.2	4	505555	253586	405
166134	30.1	4	503415	252541	321
166133	38.7	4	506437	248445	479
166130	15.8	4	503515	255818	273
166128	27	4	505543	255274	379
166125	25.3	4	503322	252386	314
166124	32	4	502643	249154	417
166121	28.1	4	502326	252351	404
166119	16.9	4	503943	255549	292
166115	39	4	506232	252351	526
166111	27.1	4	506090	255374	405
166110	30.9	4	502912	249098	401
166109	27.1	4	506184	255392	404
166108	30	4	503157	252317	318
166107	38.4	4	506423	248367	479
166106	29.9	4	503108	252266	324
166104	24.6	4	503274	252265	314
166103	25	4	503321	252259	320

21 Vestas V90 3 MW Turbine Scenario: Modeled Receiver Input Data and Results

166102	21.7	4	503275	252234	315
166101	24.7	4	504167	255804	306
166100	30.1	4	503143	252226	321
166098	33.5	4	503103	249488	394
166096	30.1	4	503082	252152	324
166095	22.7	4	503232	252099	326
166093	25.3	4	504166	255500	304
166092	24.3	4	503682	255547	279
166091	28	4	502037	251978	399
166090	29	4	503139	251952	324
166089	23	4	504366	256752	304
166087	28.3	4	503144	251923	326
166083	30.2	4	502892	251804	339
166081	26.7	4	503551	254424	328
166078	37.8	4	506726	248545	470
166076	29.6	4	502599	251782	366
166073	31	4	503327	251738	343
166072	23.8	4	504107	255761	306
166071	29	4	502347	251735	374
166069	32.8	4	503991	251717	420
166068	23.3	4	503576	255749	279
166065	25.2	4	504076	255499	301
166064	25.2	4	504120	255527	304
166063	30.5	4	503105	251626	329
166062	14.1	4	505149	256647	326
166057	30.2	4	502725	251543	350
166056	31	4	503433	251502	339
166055	36.4	4	506931	248384	473
166054	30.8	4	503456	251383	341
166053	13.7	4	502601	255629	296
166052	36.6	4	506363	252617	515
166048	22.6	4	503608	255746	276
166046	30.2	4	503418	251030	340
166044	29.9	4	503074	251834	327
166043	25.7	4	504279	255365	309
166041	24.6	4	503682	255581	277
166039	31.7	4	503479	250795	350
166038	31.9	4	503430	250742	344
166035	33.7	4	503222	250016	393
166034	16.6	4	503776	255626	277
166033	33.7	4	503188	249902	389
166026	27.1	4	504525	254845	302
166025	21.5	4	502225	256545	338
166023	13.8	4	503246	256015	263
166019	24.7	4	504089	255730	305
166017	24.7	4	506620	255486	441
166015	19.7	4	507204	255308	470
166014	22.2	4	503200	256538	271
166010	23.7	4	503825	255578	284

21 Vestas V90 3 MW Turbine Scenario: Modeled Receiver Input Data and Results

166008	14	4	504689	256550	294
166007	24.4	4	504276	256011	309
166001	24.9	4	503676	255424	292
166000	23.5	4	504258	256436	309
165999	25	4	504107	255625	304
165998	24.5	4	503663	255618	279
165996	33.4	4	507023	253348	482
165988	24.2	4	504098	255992	306
165985	24.1	4	504800	255740	333
165981	24.8	4	503574	255287	298
165975	19.8	4	503843	255575	284
165972	25	4	504107	255625	304

21 Vestas V90 3MW Scenario: Modeled Wind Turbine Input Data and Modeling Parameters

Wind Turbine	Sound Power Level (dBA)	Correction Factor (dBA)	Relative Height (m)	Coordinates (UTM NAD 83 Z18N)		Elevation (m)
				X (m)	Y (m)	
TSTATEPLNE_11-9-0900001	107	0	80	507271	252105	780
100002	107	0	80	507465	251904	773
100002	107	0	80	507251	251733	765
100002	107	0	80	507043	251387	786
100002	107	0	80	506874	251179	827
100002	107	0	80	506750	250937	801
100002	107	0	80	506480	250889	791
100002	107	0	80	506467	250621	835
100002	107	0	80	506199	250582	861
100002	107	0	80	506060	250350	883
100002	107	0	80	505942	250083	857
100002	107	0	80	505889	249800	851
100002	107	0	80	505702	249550	845
100002	107	0	80	505462	249428	813
100002	107	0	80	505197	249496	788
100002	107	0	80	505320	249002	793
100002	107	0	80	505118	248820	816
100002	107	0	80	504855	248700	798
100002	107	0	80	504644	248535	841
100002	107	0	80	504513	248297	845
100002	107	0	80	504312	248113	854

Sound Power Levels

Turbine Model	Octave Band Frequency (Hz)									dBA
	31.5	*63*	*125*	*250*	*500*	*1000*	*2000*	*4000*	*8000*	
Vestas V90 3MW	67.1	83.2	91.8	94	97.3	99.6	101.8	100.5	96.7	107

Modeling Parameters

Parameter	Setting
Ground Absorption	ISO 9613-2 Spectral, G=0
Atmospheric Absorption	Based on 10 Degrees Celsius, 70 % Relative Humidity
Reflections	None
Search Radius	2000 m from each source (1.24 miles)
Receiver Height	4 m (approximately 13 feet) for residences, 1.5 meters for grid
Contour Interval	5.0 m (16.4 ft) from USGS digital elevation model

Kingdom Community Wind Substation: Modeled Receiver Input Data and Results

Receiver	Modeled Sound Pressure Level (dBA)	Relative Height (m)	Coordinates (UTM NAD 83 Z18N)		Elevation (m)
			X (m)	Y (m)	
Stackpole-French Camp	0.2	4	507281	252749	567
Nelsons	-15.7	4	507293	249450	456
Mygatt Camp	-19.2	4	507589	251038	531
Irish Farm Road	7	4	506344	252319	533
Gebbie Camp	-17.2	4	505353	248444	587
Corrow Camp	-6.5	4	504888	246953	518
1135000	-2.7	4	502568	248652	442
196675	-20.7	4	507541	248316	455
196662	-23.3	4	509618	248159	299
196655	-28.6	4	509110	248023	320
196654	-21.4	4	508048	248263	420
196651	-23.7	4	509430	247895	304
196644	-9.2	4	507888	248584	437
196643	-22.4	4	509633	248076	299
196637	-20.8	4	507472	248104	459
196628	-22.9	4	509484	247851	301
196627	-9.2	4	508643	248154	349
196626	-11	4	509583	247568	287
196621	-22.6	4	509520	247925	304
196618	-25.2	4	509392	248020	309
196615	-26.9	4	509603	248340	299
196604	-26	4	509295	247985	309
196603	-22.7	4	509514	247866	301
196602	-32.5	4	508883	245949	287
196595	-21.6	4	507855	248449	440
196593	-25.6	4	509352	248013	309
196589	-20.9	4	507731	248424	445
196587	-9	4	508586	248019	367
196581	-30.9	4	509028	247042	293
196579	-10.6	4	509470	247674	292
196573	-22.9	4	509515	247888	302
196571	-25.1	4	509389	248005	309
196566	-26.1	4	509425	247631	289
196562	-31.9	4	508974	246339	291
196554	-11	4	509611	247563	285
196552	-25.9	4	509328	248018	309
196540	-28	4	508357	247139	359
196539	-10.5	4	509442	247716	295
196530	-23	4	509566	248054	303
196527	-21	4	507287	248241	476
196526	-20.8	4	507654	248433	449
196520	-23.9	4	509463	247968	306
196519	-11	4	509652	247597	282
196513	-23	4	509548	248014	304
196497	-25.7	4	509586	248230	300

196494	-23.3	4	509436	247848	302
196489	-22.2	4	509562	247916	301
196487	-21	4	507437	248352	461
196480	-26.7	4	509288	248050	311
196477	-23.4	4	509517	248008	305
196475	-24.6	4	509423	247990	308
196469	-21.9	4	509571	247863	299
196460	-9.3	4	508505	248200	359
196458	-32	4	508738	246248	313
196452	-26.6	4	509438	247657	291
196449	-31.9	4	508744	246302	311
196446	-26.4	4	509321	248047	309
196434	-10.9	4	509588	247607	286
196427	-26.9	4	509375	249928	327
196417	-10.5	4	509527	247809	299
196412	-27.5	4	509602	248469	298
196407	-25.8	4	509660	248630	291
196386	-23.6	4	509624	248188	299
196382	-25.4	4	509322	247951	305
196381	-26.1	4	509383	247590	286
196378	-25.3	4	509683	248601	291
196372	-10.5	4	509471	247756	297
196365	-22.7	4	509595	248052	301
196356	-10.5	4	509540	247843	300
196350	-24.5	4	509376	247912	304
196343	-22.2	4	509603	247989	299
196342	-22.9	4	509524	247978	304
196339	-23	4	509473	247858	301
196327	-25.5	4	509287	247940	306
196317	-22.2	4	509549	247869	301
196312	-11	4	509604	247602	285
196310	-31.7	4	509072	246476	298
196300	-20.8	4	507537	248488	454
196287	-24.6	4	509423	248006	308
196281	-8.8	4	507951	248482	430
196279	-26.9	4	508028	247942	419
196269	-10.6	4	509514	247732	296
196267	-32.3	4	508750	246121	303
196254	-26.3	4	507997	248160	432
196250	-24.7	4	509333	247910	303
196248	-22.6	4	509668	248134	297
196245	-28.3	4	509215	248103	317
196244	-22.6	4	509573	247974	301
196242	-20.2	4	507590	248083	464
196224	-23.3	4	509572	248101	302
196222	-29.4	4	509706	248783	287
196221	-23.9	4	509462	247993	307
196219	-23.9	4	509380	247870	303
196218	-31.9	4	509067	246327	287

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196207	-24.4	4	509654	248178	297
196205	-10.4	4	509465	247793	299
196195	-22.3	4	509629	248122	300
196193	-10.6	4	509444	247679	292
196189	-27.4	4	509256	248083	314
196188	-22.3	4	509544	247888	302
196187	-10.1	4	507638	248754	449
196185	-22.4	4	509594	248015	301
196181	-10.6	4	509501	247702	294
196179	-30.7	4	509278	246556	289
196177	-22.5	4	509692	248164	295
196174	-22.4	4	509559	247941	302
196172	-25.6	4	509364	248025	309
196171	-8.8	4	508767	248287	371
166495	-9.9	4	502216	256507	338
166486	6.9	4	503002	250280	406
166485	7.1	4	503441	252335	324
166484	6.2	4	503206	252165	318
166480	-4.8	4	503969	255483	299
166476	-7.7	4	502191	255423	305
166475	-4.7	4	504240	256387	310
166474	-5.4	4	503851	255624	288
166473	-5.8	4	503636	255692	280
166470	-7	4	506113	248061	489
166469	-7.3	4	503114	255954	269
166465	-7.2	4	504099	256229	313
166461	-4	4	504275	255279	305
166460	1.7	4	503132	256528	277
166458	-5.3	4	505778	247417	489
166456	-4.9	4	504137	255574	305
166453	-4.5	4	504822	255467	332
166452	-3.7	4	504015	255132	287
166448	-4.8	4	505994	255376	409
166446	-5.7	4	503708	255673	277
166445	-4.6	4	504214	256356	308
166433	-5.9	4	504121	255938	304
166432	9.1	4	502914	251670	342
166426	-9.5	4	507195	256516	425
166423	2.9	4	503339	249586	393
166421	5.9	4	504049	253061	306
166420	-5.1	4	503691	255449	286
166419	-21.5	4	506244	248328	484
166417	-4.7	4	503674	255376	291
166414	-5	4	507465	254702	449
166413	-5.2	4	504103	255669	306
166408	-4.2	4	503868	255246	286
166407	-1.6	4	504073	254626	294
166401	-3.1	4	507411	254090	452
166398	0.4	4	504036	254148	294

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166397	0.5	4	504024	254128	294
166395	-5.3	4	505697	247493	500
166394	-8.9	4	507571	256096	429
166393	0.2	4	504084	254198	294
166391	0.4	4	504057	254150	294
166390	4.9	4	503332	252752	317
166386	-4.6	4	504096	255446	300
166385	-3.1	4	504563	255064	307
166384	0.6	4	504767	254224	324
166383	-5.7	4	503635	255663	283
166381	-21.7	4	507060	248342	476
166380	-5.9	4	503617	255725	277
166378	-4.7	4	507866	254220	494
166377	-4.2	4	505880	255233	398
166376	-6	4	506473	255594	426
166375	-1.2	4	504577	254604	314
166373	-0.2	4	504090	254308	294
166369	-7.5	4	504177	256309	304
166367	-0.5	4	504198	254385	306
166366	-9.1	4	507705	256064	436
166363	3.2	4	505418	253674	394
166361	-2.4	4	503537	255123	311
166358	-2.2	4	504102	254777	294
166357	-5.7	4	503717	255648	274
166355	-5.2	4	504120	255722	308
166354	-12.9	4	502007	255229	301
166351	-0.9	4	503636	254594	319
166344	-5	4	503889	255512	292
166343	3.1	4	503222	249722	384
166339	0	4	504618	254353	319
166338	-3.9	4	507411	254359	444
166336	-0.1	4	504689	254368	320
166335	-7.4	4	503308	256043	261
166332	0.2	4	503509	254482	338
166331	-0.3	4	503566	254518	326
166330	-2.9	4	507274	254135	440
166329	-2.6	4	504084	254867	290
166328	-1	4	504556	254568	314
166327	-9.8	4	507283	256566	420
166325	-0.8	4	503602	254581	321
166324	10.7	4	502040	252120	397
166320	-1.8	4	504450	254747	304
166319	-5.2	4	504586	255642	316
166318	-5.8	4	503604	255700	282
166317	-4.4	4	503782	255272	286
166316	-3.8	4	504195	255211	289
166314	1.1	4	504845	254123	332
166313	-4.2	4	505965	255228	403
166311	-21.6	4	507100	248425	479

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166309	-8.3	4	503110	256276	263
166308	-3.8	4	504058	256128	316
166304	-7.5	4	503177	256042	259
166303	1.4	4	504791	254067	326
166301	0.8	4	504039	254062	298
166295	-2	4	504102	254713	294
166294	-4.6	4	503622	255278	294
166293	-5.1	4	504134	255689	308
166292	-3.9	4	505830	255178	391
166289	-3.4	4	504258	255123	289
166288	-5.6	4	503750	255617	274
166283	-7.4	4	503084	255916	271
166282	2.2	4	505075	253903	356
166280	0.7	4	506179	253894	421
166277	-5.2	4	503750	255526	279
166275	-3.9	4	503931	256161	312
166274	-3.2	4	504406	255076	296
166271	1.2	4	506070	253829	417
166270	2.8	4	504878	253801	345
166268	-2.4	4	504082	254829	291
166267	2.8	4	505077	253801	364
166263	2.8	4	505195	253780	372
166262	2.2	4	503860	253711	303
166261	-1.6	4	504586	254704	311
166260	2.4	4	505887	253669	419
166258	-4.3	4	503580	255267	298
166256	-5.7	4	503611	255683	283
166255	-3.7	4	504105	255150	287
166254	-3.6	4	504077	255121	287
166253	-5	4	504130	255616	305
166252	-10.5	4	507703	256676	439
166250	-3.2	4	504062	255902	304
166245	-5.4	4	503666	255524	281
166244	-5.5	4	507278	255011	471
166243	0.5	4	506661	253627	439
166241	0.3	4	503956	254147	302
166240	3.3	4	505633	253598	409
166239	2.7	4	503148	249695	390
166238	3.8	4	505463	253550	406
166236	6.9	4	503862	252811	324
166235	-2.4	4	504084	254815	292
166232	0.1	4	506723	253678	436
166230	3.2	4	505881	253511	425
166229	-4.3	4	503842	255260	286
166228	-5.8	4	503657	255684	279
166227	-3.5	4	504263	255144	289
166225	-3.3	4	504284	255092	293
166224	-5.6	4	503681	255598	277
166219	-4.9	4	504023	255521	299

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166216	2.6	4	506056	253540	429
166215	-3.1	4	504096	254994	287
166213	1	4	503079	249328	395
166212	0	4	502975	249134	401
166211	2	4	506415	253433	446
166205	-3.8	4	505169	255258	358
166204	-0.1	4	507103	253383	491
166201	3.8	4	503828	253374	315
166200	-5.5	4	503655	255594	281
166198	-6.7	4	503481	255873	273
166195	4	4	505947	253307	440
166193	-3.9	4	503658	255098	299
166191	-5	4	503915	255519	292
166189	-3.9	4	503914	255176	284
166186	4.6	4	503817	253200	304
166185	-5.6	4	503170	256687	270
166183	-5	4	504397	255569	313
166178	4.8	4	503696	253096	304
166174	4.9	4	503655	253042	310
166170	12.8	4	502886	252918	373
166169	1.1	4	503026	249404	394
166167	4.9	4	505980	253130	457
166166	3.1	4	505289	253719	385
166163	8.8	4	503177	254310	369
166159	-5.7	4	504076	255858	304
166154	5	4	503388	252786	314
166150	8	4	505866	252646	485
166149	-5.5	4	503660	255567	280
166142	12.5	4	502630	252648	402
166139	6.3	4	503141	251962	324
166137	6	4	503421	252575	324
166135	3.5	4	505555	253586	405
166134	6.1	4	503415	252541	321
166133	-21.5	4	506437	248445	479
166130	-6.5	4	503515	255818	273
166128	-4	4	505543	255274	379
166125	6.2	4	503322	252386	314
166124	1	4	502643	249154	417
166121	11.7	4	502326	252351	404
166119	-5.2	4	503943	255549	292
166115	7.5	4	506232	252351	526
166111	-4.9	4	506090	255374	405
166110	0.2	4	502912	249098	401
166109	-5	4	506184	255392	404
166108	5.5	4	503157	252317	318
166107	-21.4	4	506423	248367	479
166106	5.7	4	503108	252266	324
166104	6.3	4	503274	252265	314
166103	6.7	4	503321	252259	320

166102	6.4	4	503275	252234	315
166101	-5.6	4	504167	255804	306
166100	5.7	4	503143	252226	321
166098	1.7	4	503103	249488	394
166096	5.6	4	503082	252152	324
166095	6.6	4	503232	252099	326
166093	-4.7	4	504166	255500	304
166092	-5.4	4	503682	255547	279
166091	10.9	4	502037	251978	399
166090	6.3	4	503139	251952	324
166089	-8.4	4	504366	256752	304
166087	6.4	4	503144	251923	326
166083	8.9	4	502892	251804	339
166081	-0.1	4	503551	254424	328
166078	-22	4	506726	248545	470
166076	8	4	502599	251782	366
166073	8.1	4	503327	251738	343
166072	-5.4	4	504107	255761	306
166071	12.6	4	502347	251735	374
166069	18	4	503991	251717	420
166068	-6	4	503576	255749	279
166065	-4.8	4	504076	255499	301
166064	-4.8	4	504120	255527	304
166063	6.6	4	503105	251626	329
166062	-8.5	4	505149	256647	326
166057	8.2	4	502725	251543	350
166056	9.1	4	503433	251502	339
166055	-21.9	4	506931	248384	473
166054	9.4	4	503456	251383	341
166053	-7.1	4	502601	255629	296
166052	5.7	4	506363	252617	515
166048	-6.1	4	503608	255746	276
166046	8.6	4	503418	251030	340
166044	6.3	4	503074	251834	327
166043	-4.3	4	504279	255365	309
166041	-5.5	4	503682	255581	277
166039	7.5	4	503479	250795	350
166038	7.8	4	503430	250742	344
166035	4.9	4	503222	250016	393
166034	-5.6	4	503776	255626	277
166033	3.6	4	503188	249902	389
166026	-2.2	4	504525	254845	302
166025	-10	4	502225	256545	338
166023	-7.3	4	503246	256015	263
166019	-5.3	4	504089	255730	305
166017	-5.9	4	506620	255486	441
166015	-6.2	4	507204	255308	470
166014	-6.9	4	503200	256538	271
166010	-5.3	4	503825	255578	284

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166008	-8.2	4	504689	256550	294
166007	-6.3	4	504276	256011	309
166001	-4.9	4	503676	255424	292
166000	-4.9	4	504258	256436	309
165999	-5.1	4	504107	255625	304
165998	-5.6	4	503663	255618	279
165996	0.3	4	507023	253348	482
165988	-3.5	4	504098	255992	306
165985	-5.5	4	504800	255740	333
165981	-4.3	4	503574	255287	298
165975	-5.3	4	503843	255575	284
165972	-5.1	4	504107	255625	304

Kingdom Community Wind Substation: Modeled Transformer Input Data and Modeling Parameters

Transformer	Sound Power Level (dBA)	Relative Height (m)	Coordinates (UTM NAD 83 Z18N)		Elevation (m)
			X (m)	Y (m)	
KCW	92.9	3	504870	251406	512

Sound Power Levels

Transformer	Octave Band Frequency (Hz)									dBA
	31.5	*63*	*125*	*250*	*500*	*1000*	*2000*	*4000*	*8000*	
KCW transformer	41	59	73	85	86	88	86	82	71	92.9

Modeling Parameters

Parameter	Setting
Ground Absorption	ISO 9613-2 Spectral, G=0
Atmospheric Absorption	Based on 10 Degrees Celsius, 70 % Relative Humidity
Reflections	None
Search Radius	2000 m from each source (1.24 miles)
Receiver Height	4 m (approximately 13 feet) for residences, 1.5 meters for grid
Contour Interval	5.0 m (16.4 ft) from USGS digital elevation model

Jay Substation: Modeled Receiver Input Data and Results

Receiver	Modeled Sound Pressure Level (dBA)	Relative Height (m)	Coordinates (UTM NAD 83 Z18N)		Elevation (m)
			X (m)	Y (m)	
1	35.7	4	504854	271827	293
2	30.8	4	504866	271951	289
3	20.1	4	504703	271737	303
4	26.2	4	504823	271992	289
5	31.6	4	504933	271961	288

Jay Substation: Modeled Transformer Input Data and Modeling Parameters

Transformer	Status	Sound Power Level (dBA)	Relative Height (m)	Coordinates (UTM NAD 83 Z18N)		Elevation (m)
				X (m)	Y (m)	
Existing Transformers	Removed	61.9	2	504929	271838	285
Existing Transformers	Removed	61.9	2	504930	271838	285
Existing Transformers	Removed	61.9	2	504927	271838	285
New Transformer	On	86	4	504932	271841	290

Sound Power Levels

Transformer	Octave Band Frequency (Hz)									dBA
	31.5	*63*	*125*	*250*	*500*	*1000*	*2000*	*4000*	*8000*	
Jay #17 34.5 to 12.47 kV	52.3	55.5	69.3	63.3	63.1	48.1	39.7	35.3	24.8	61.9
34.5/12.47 kV 250 kV BIL NEMA 67/70 dBA	85.8	34.4	52.3	65.7	77.5	79.1	80.7	79.2	75.3	86

Modeling Parameters

Parameter	Setting
Ground Absorption	ISO 9613-2 Spectral, G=1
Atmospheric Absorption	Based on 10 Degrees Celsius, 70 % Relative Humidity
Reflections	None
Search Radius	2000 m from each source (1.24 miles)
Receiver Height	4 m (approximately 13 feet) for residences, 1.5 meters for grid

Lowell Substation: Modeled Receiver Input Data and Results

Receiver	Modeled Sound Pressure Level (dBA)	Relative Height (m)	Coordinates (UTM NAD 83 Z18N)		Elevation (m)
			X (m)	Y (m)	
1	26.8	4	504251	256053	307
2	32.3	4	504069	255873	304
3	27.6	4	504054	256110	313
4	31.2	4	504172	255818	304

Lowell Substation: Modeled Transformer Input Data and Modeling Parameters

Transformer	Status	Sound Power Level (dBA)	Relative Height (m)	Coordinates (UTM NAD 83 Z18N)		Elevation (m)
				X (m)	Y (m)	
CVPS	On	78.4	3	504141	255904	303
L5Existing	Removed	63.9	4	504140	255921	303
Irasburg	Removed	60.7	2	504180	255966	303
New	On	86	3.9	504165	255963	305

Sound Power Levels

Transformer	Octave Band Frequency (Hz)									dBA
	31.5	*63*	*125*	*250*	*500*	*1000*	*2000*	*4000*	*8000*	
CVPS 46 kV/34.5 kV	62	61.9	69	84.2	76.4	70.5	58.6	51.8	39.5	78.4
L5 Existing LowellVEC	63	61.8	66.8	67.2	64	55.5	47.2	35.5	28.8	63.9
Irasburg #21 34.5 kV/14.4 kV single phase	59.6	62.3	55.1	59.6	61.3	55.4	45.8	29.7	25.6	60.7
New 34.5/12.47 kV 250 kV BIL NEMA 67/70 dBA	85.8	34.4	52.3	65.7	77.5	79.1	80.7	79.2	75.3	86

Modeling Parameters

Parameter	Setting
Ground Absorption	ISO 9613-2 Spectral, G=1
Atmospheric Absorption	Based on 10 Degrees Celsius, 70 % Relative Humidity
Reflections	None
Search Radius	2000 m from each source (1.24 miles)
Receiver Height	4 m (approximately 13 feet) for residences, 1.5 meters for grid